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A STUDY

OF

METHODS OF MINE VALUATION AND ASSESSMENT

WITH SPECIAL REFERENCE TO THE ZINC MINES OF SOUTHWESTERN WISCONSIN

BY

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CHAPTER I: INTRODUCTION.

A. Purpose of the Paper, and Acknowledgments.

In recent years, considerable attention has been given in the United States to the subject of taxation of mining property. The literature abounds with various treatments of the subject, both from the point of view of the taxing power and of the mining community. It must be recognized that the country is entering upon a new era of mine taxation. Continually increasing emphasis is being laid upon the gross underassessment of mines in the past, as compared with the assessment of other kinds of property. Arizona, Colorado, Nevada, Minnesota and Michigan are rife with discussion of the subject, and widely different methods are being used in those states in an endeavor to reach more equitable results.

In August, 1913, the Wisconsin Legislature passed a bill whereby the State Geological and Natural History Survey was instructed to place valuations on the mines and mineral lands of the state for the Tax Commission. In compliance with this Act, the writer was sent by the Survey into the zinc and lead district of southwestern Wisconsin to make a study of geologic and mining conditions with a view to working out some fair method of valuing the mines for purposes of assessment. A method of appraisal was tentatively adopted, in accordance with which valuations were placed on the mines. These valuations have been made the basis of the 1914 assessment.

Before the work of appraisal was completed, however, it became evident that, owing to unforeseen local contingencies, the method adopted was not giving sufficiently accurate results. At that time no other

method capable of giving better satisfaction seemed available. Consequently the work was carried through to completion, on the basis originally selected. After the completion of the appraisal work, the writer was instructed to make a study of various methods of valuation and assessment in the light of the first year's experience and results, and to find out if possible the most satisfactory solution of the problem of mine assessment for this district. The co-operation of the various mining companies in the work of appraisal has afforded an excellent opportunity for taking up this study in considerable detail; and the results thereof are presented in this paper for the consideration of the mining community and others interested in the subject.

This study of mine valuation and assessment was undertaken at the suggestion and under the direction of Mr. W. O. Hotchkiss, State Geologist of Wisconsin, and to him the writer feels keenly indebted for his kindly interest and assistance. Especial acknowledgments are also cheerfully accorded to Dr. T. S. Adams, of the Wisconsin Tax Commission, to Dr. C. K. Leith, Professor of Geology, University of Wisconsin, to Mr. W. N. Smith, Manager of the Vinegar Hill Zinc Company, and to all the larger mining companies of southwestern Wisconsin, for their valuable advice and co-operation during the preparation of this paper.

B. General Statement of Conclusions.

The 1914 assessment of the mines was based on a series of valuations worked out approximately on the Finlay ad valorem method. The exploratory, geologic and mining conditions are such that any system of valuation which has its basis in future probable profits must necessarily cause inequitable assessments.

In order to make the treatment that follows as concrete as possible, a "hypothetical zinc mine" is constructed and studied in the light of various systems of valuation and assessment. Owing to the fact that the general property system is with few exceptions the corner stone of property taxation in Wisconsin, the results of any method of assessment should be judged from the point of view of that system as a standard. Detailed criticism of the various methods herein studied are given at the ends of Chapters II to VII, in Part II. A general comparison of the Finlay and "Equated Income"* methods, which are the only two that appear to give anything in the nature of equitable results, from the viewpoint of the general property system as a standard, is given in Part II, Chapter VIII.

*See Part II, Chapter VII.

CHAPTER II: PECULIAR CONDITIONS IN THE ZINC DISTRICT WHICH HAVE AN IMPORTANT INFLUENCE ON THE PROBLEM OF VALUATION AND ASSESSMENT.

In order to make the subsequent discussion of zinc mine assessment intelligible to readers not well acquainted with the district, a brief description of certain peculiar local conditions becomes necessary. The specific bearing of these conditions on the various methods of assessment to be discussed will be taken up in Part II, but references will be made to their descriptions in the present chapter. The essentials of these conditions may be conveniently discussed under the following headings.

A. Wisconsin Law in Regard to Taxation of Mineral Rights.

Laws of Wisconsin, Section 1052: "Real property shall be valued by the assessor from actual view or from the best information that the assessor can practically obtain, at the full value which could ordinarily be obtained therefor at private sale. In determining the value, the assessor shall consider, as to each piece, its advantage or disadvantage of location, quality of soil, quantity of standing timber, water privileges, *mines, minerals, quarries, or other valuable deposits known to be available thereon, and their value.** But the fact that the extent and value of minerals or other valuable deposits in any parcel of land are unascertained shall not preclude the assessor from affixing to such parcel the value which could ordinarily be obtained therefor at private sale."

Section 1042 j. "1. Any and all rights and reservations to enter upon and take away any mineral from any lands within the state of Wisconsin, granted by or reserved in any deed or conveyance of such lands, the title to which right or reservation is vested or may hereafter become vested in any person or corporation other than the owner of the fee to which such right or reservation is attached, is hereby declared to be taxable; and the same shall be separately assessed for taxation, and like proceedings shall be had thereon relating to the levy, collection and sale thereof for the non-payment of taxes against said reservation as are in force from time to time for the levy and collecting of taxes on real estate and the sale of the same for the non-payment of taxes * * *

* Italics are the writer's.

"4. Nothing in this act, however, shall extend to mining leases, made as such in good faith, which are terminable upon failure to fulfill the terms and conditions of such leases."

Under the above law, the value of mineral rights is an integral part of the value of the surface under which they lie, provided they are not vested in any person or corporation other than the owner of the surface rights. That is to say, if the owner of the surface leases his mineral rights to a second party, for the purposes of taxation there is no separate assessment of such mineral rights. The value of the mineral rights forms part of the real estate assessment against the fee owner. On the other hand, if the mineral rights of a certain piece of land are alienated by sale to some second party, then they are separately assessed for taxation against the said party on the same basis as real estate.

Article VIII, Section I. of the Constitution, as amended by a vote of the people at the General Election, November 3, 1908, reads as follows: "The rules of taxation shall be uniform, and taxes shall be levied upon such property, as the Legislature shall prescribe. Taxes may also be imposed on incomes, privileges and occupations, which taxes may be graduated and progressive, and reasonable exemptions may be provided."

According to this clause, the Legislature has the power to exempt from taxation any class of property, provided such exemption be in accordance with the law of uniformity of taxation.

In addition to the real property assessment, the surface plant and equipment and the ore on hand, are assessed as personal property against the operating company. Besides these general property taxes, the state levies an income tax on all persons and corporations having incomes above certain stated amounts. The amount of the personal property tax in all cases is subtracted from the amount of the income tax if the latter is in excess. The point which it is wished to emphasize in the situation under discussion is that the fee owner, like all other owners of real property, pays a real property tax on the mine as well as an income tax on the income from that mine.

B. The Actual Status of Mine Assessment in Southwestern Wisconsin Previous to 1914.

The problem of valuing the zinc and lead mines of Wisconsin for assessment purposes, as presented to the State Geological Survey in 1913, abounded with difficulties. According to the law of Wisconsin as given above, mineral rights have been assessable as real estate under the general property system of taxation for several years. Inspection of as-

sessment rolls has shown, however, that as a general rule very little increased assessment has been placed upon mining lands in the past on account of its mineral content. A few cases have come to light, on the other hand, where strikingly excessive valuations have been placed by the local assessors upon certain mining properties. It was in an attempt to rectify such inequities that the Legislature instructed the State Geological Survey to obtain complete records of operations from the mining companies with a view to determining at least approximately the reasonable sale values of the various properties. One of the most troublesome features of the work as a whole was that according to the method of holding mining leases in this district, the leasing company, except in very few instances, did not undertake to pay any taxes with the exception of those on income and personal property. The matter of real property taxes on mineral rights had been almost entirely overlooked. When attention was directed to this aspect of real property assessment, it became incumbent upon the appraisors to ask each mining company for details of production, receipts, costs and profits in order to determine a real property assessment against the fee owner, whose only interest in the property lies in his royalty.

C. Ownership of Mineral Rights and Tax Incidence.

The mining district of southwestern Wisconsin is located in the center of a rich farming constituency, and the fee owners are usually farmers. The prevalent custom is for an operating company to lease ore-bearing land from the fee owner. In consideration of this lease, the company proceeds to drill, sink shafts on, develop and mine any ore body that is found thereon. A royalty, usually 10 per cent of gross receipts, (but sometimes varying between 5 per cent and 15 per cent) is paid to the fee owner as rent, or his share in the earnings of the mine. Unless otherwise stated in the lease, the fee owner undertakes to pay all real property taxes on his fee. As a consequence of the presence of an ore body, he pays a real property tax on an increased assessment, due to the increased value of his land, as well as an income tax on his royalty from the mine.

Occasionally, a mining company prefers to buy outright the land on which it intends to mine. In this case, the said company undertakes to pay all taxes on the property, and on income from the property. The surface is usually leased to some other party.

Again, there are cases where a mining company, after buying the land outright, sells the surface. Section 1042 j of the Laws of Wisconsin

covers this situation and states that the mineral rights shall in such a case be assessed separately on the same basis as real estate, that is, to the fee owners of the mineral rights.

D. Essential Features of the Geology and Mining.

Several published descriptions of the general geology and mining methods of the district are available, a few of which are listed in the bibliography at the end. A full treatment of this branch of the industry is out of the realm of this discussion. It is simply necessary here to mention briefly a few salient facts concerning the geology and mining, sufficient to render the subsequent study of the "hypothetical zinc mine" intelligible to readers not acquainted with the local details.

1. The ore bodies have their greatest extent horizontally rather than vertically. They vary in dimensions as follows: length, from about 100 feet to about 5,000 feet; width, from about 10 feet to about 1500 feet; thickness, from about 4 feet to about 80 feet. The bottom varies in different mines, according to the locality, from a few feet to about 250 feet below the surface.

2. The chief metallic constiutents—sphalerite, iron sulphides, and galena—occur disseminated and in veins in Trenton and Galena limestone and dolomite, and at times constitute by weight as much as 15 to 20 per cent of the total rock mined. The mixed ore and rock as broken in the mine and hoisted into the mill is known as "dirt".

3. The general practice is to cull out of the dirt as broken whatever barren or dead pieces may be conveniently thrown out. This is done either underground where the waste is piled up or "gobbed", or just before the dirt enters the mill, when it is thrown from a grizzley into the bowlder pile. The amount of broken rock discarded runs up to 60 or 70 per cent in the former case, and up to about 20 per cent in the latter.

4. Two products result from the milling practices, a galena or "lead" concentrate, which usually averages between 70 and 80 per cent lead, and a sphalerite-iron sulphide or "zinc" concentrate running between 20 and 60 per cent zinc. The average grade of zinc concentrates for Wisconsin is now between 35 and 38 per cent. The galena, when not too intimately mixed with the zinc blende to admit of easy separation, is usually considered as "velvet" or clear profit.

5. Iron sulphide is locally known as "sulphur", zinc sulphide is usually called "jack", galena is known as "lead", and calcite is called "tiff".

6. A planimeter computation made from several mine maps showed

that approximately 10 per cent of the volume of crude ore (ore and country rock in place) in a deposit is left in the mine as pillars and not recovered.

7. The number of tons of zinc and lead concentrates recoverable from one hundred tons of dirt is spoken of as the "grade of the dirt". It is usually given in per cent.

8. Figures for mill recovery as far as they are at present available, show that of the metallic zinc that enters the mill in the "mill dirt" about 70 to 75 per cent is saved in the concentrates. Of the metallic iron that goes through the mill, the saving varies from about 30 to 50 per cent.

9. Roasting and smelting operations do not effect the problem of the valuation and assessment of the mines. Concentrates from the mills are either sold, or considered as sold, to these concerns.

E. Exploratory Practice.

1. The most efficient companies do just sufficient drilling to ensure themselves that the ore body is large and rich enough to justify the necessary expenditure for development and equipment. Even this practice is far from general.

2. Churn drills alone are used, and when ore is first struck, average samples of the cuttings are taken about every two feet. These samples are either assayed individually for zinc, iron, and lead, or a composite sample of every two feet of cuttings from the time ore is first struck until it is lost, is made for each hole. Considerable inaccuracies occur in the estimation of ore reserves from these assays, due in large part to (a) natural breaks or openings in the rocks which carry away a part of the cuttings, (b) the degree of fineness of the disseminated "sulphur", (c) and whether or not the drill cuts perpendicularly or obliquely across a vein.

3. Many of the smaller companies, of which there are a large number, do practically no exploratory drilling and have little or no reserve blocked out in advance of working breasts.

F. Estimation of Ore Reserves.

The locations of the drill holes are platted on a map, and the boundary of the ore body is considered as a line joining the outside holes that are in ore. The included area is measured. The arithmetic total of the thicknesses of minable ore shown by each hole in this area is divided by the number of holes. The result gives an approximate

figure for the average thickness of the ore body. In arriving at the figure used for the thickness to be included as dirt in each hole, consideration must be taken of absolute elevations of the ore traversed, for in several cases dead rock must be included in the average so as to get working grades on haulage levels.

The area in square feet multiplied by the thickness in feet and divided by the average number of cubic feet of mineralized rock per ton gives the total tonnage of reserve ore. In these computations the figure 12 is taken as the average number of cubic feet per ton.

GRADE OF DIRT AND GRADE OF CONCENTRATES.

The general method of estimating these can best be described by means of an example as below:

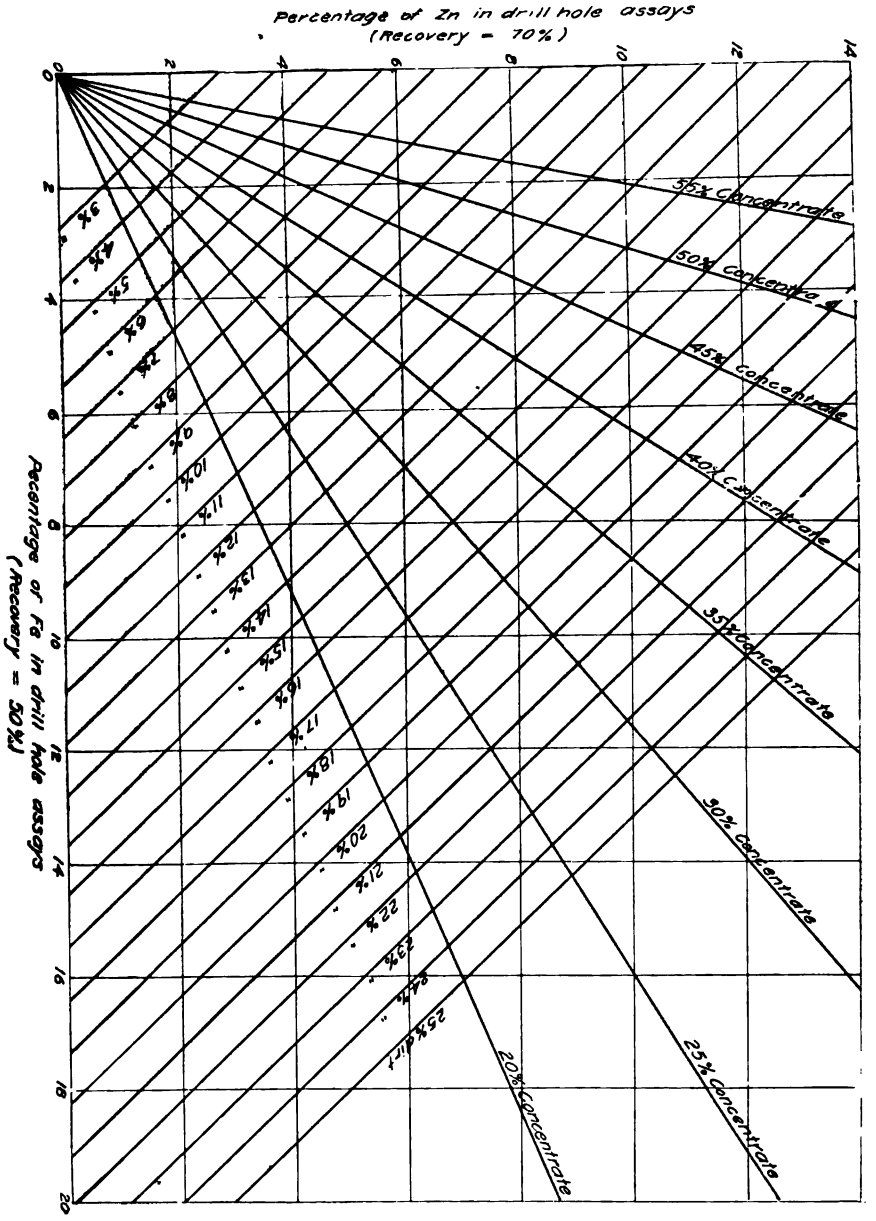
	I. No. of hole.	II. Thickness of ore in feet.
	1	a_1
	2	a_2
	3	a_3
	4	a_4
	5	a_5
Totals:	5	$a_1+a_2+\ldots\ldots+a_5$

The average assay of the ore body as cut by the drill in each hole is obtained by taking the weighted average of all footage assays from the time minable ore is first struck until it is lost. Intervening dead ground must be included in making up the average at its thickness with zero per cent of zinc and iron. (Columns III and IV). The average assay of zinc and iron in each hole is multiplied by the thickness of ore in the hole. (Columns V and VI).

III. Average per cent of zinc.	IV. Average per cent of iron.	V. Column III x Column II.	VI. Column IV x Column II.
z_1	r_1	z_1a_1	r_1a_1
z_2	r_2	z_2a_2	r_2a_2
z_3	r_3	z_3a_3	r_3a_3
z_4	r_4	z_4a_4	r_4a_4
z_5	r_5	z_5a_5	r_5a_5
Totals		$z_1a_1+\ldots\ldots+z_5a_5$	$r_1a_1+\ldots+r_5a_5$

The totals of columns V and VI are separately divided by the total of Column II. The result will be the average assay of the ore body:

$$\text{Average per cent zinc} = \frac{z_1a_1 + \ldots\ldots + z_5a_5}{a_1 + \ldots\ldots + a_5} = Z$$


Percentage of Zn in drill hole assays
(Recovery = 70%)
0
2
4
6
8
10
12
14
16
18
20
55% Concentrate
50% Concentrate
45% Concentrate
40% Concentrate
35% Concentrate
30% Concentrate
25% Concentrate
20% Concentrate
Percentage of Fe in drill hole assays
(Recovery = 50%)
.46
.44
.45
.49
.42
.48
.40
.401
.411
.421
.461
.481
.451
.491
.421
.481
.461
.402
.412
.422
.432
.442
.452 drift

$$\text{Average per cent iron} = \frac{r_1a_1 + \ldots\ldots + r_sa_s}{a_1 + \ldots\ldots + a_s} = R$$

Let m = recovery of zinc in the mill

Let n = recovery of iron in the mill

Let y = average percentage of zinc and iron sulphides in a ton of zinc concentrates. Then 100 — y = percentage of gangue minerals.

Now, 1.5 = factor by which a weight of metallic zinc is multiplied to get its equivalent weight of zinc sulphide (ZnS).

Now, 2.2 = factor by which a weight of metallic iron is multiplied to get its equivalent weight of iron sulphide (FeS_2).

Per cent of zinc.	Per cent of iron.	
Z	R	Average assay of ore body.
m	n	Mill recovery percentages.
mZ	nR	Percentages of metals coming out of the mill.
1.5	2.2	Sulphide factors.
1.5mZ	2.2nR	Percentages of sulphides coming out of the mill.

Total percentage of sulphides coming out of the mill=(1.5mZ + 2.2nR). This quantity multiplied by $\frac{y}{100}$ will give the percentage of concentrates coming from the mill. Hence 100 tons of dirt will give: $\frac{100(1.5mZ + 2.2nR)}{y}$ tons of zinc concentrates. This is the figure representing the estimated grade of dirt.

From the above calculation, it is seen that every 100 tons of dirt will produce mZ tons of metallic zinc. This tonnage will therefore also be contained in the $\frac{100(1.5mZ + 2.2nR)}{y}$ tons of zinc concentrates. Consequently the percentage of zinc in the concentrates or the "grade of the concentrates" will be given by the expression:

$$\frac{mZy}{100\ (1.5mZ + 2.2nR)} \times 100$$

Different operators use quite different values for the factors m, n, and y. The accompanying diagrams (Plates I and II) give graphically the above results for grades of dirt and zinc concentrates from average assays. In Plate I the following values are used:

m = 0.70, n = 0.50, y = 100.
In Plate II, m = 0.70, n = 0.36, y = 91.61.

These are sets of values in fairly common use in the district. Both diagrams are given to show the rather wide variation in results obtained by the use of different factors. Consequently any estimate of ore reserves based on drill hole data can as yet only be very approximate. The significance of this will be shown later, in the discussion of the Finlay system of valuation.

In order to illustrate the discrepancy in results obtained from the same set of average assays by the use of the two diagrams let it be assumed that an ore body assays Zn: 9.0 per cent and Fe: 6.0 per cent.

From Plate I.

Find the intersection of the horizontal line through 9.0 on the zinc scale, and the vertical line through 6.0 on the iron scale. The position of this point with respect to the lines representing grade of dirt shows that the grade of dirt is about 16.1 per cent. Its position with respect to the lines representing grade of concentrates shows that the grade of concentrates is about 39.1 per cent.

From Plate II.

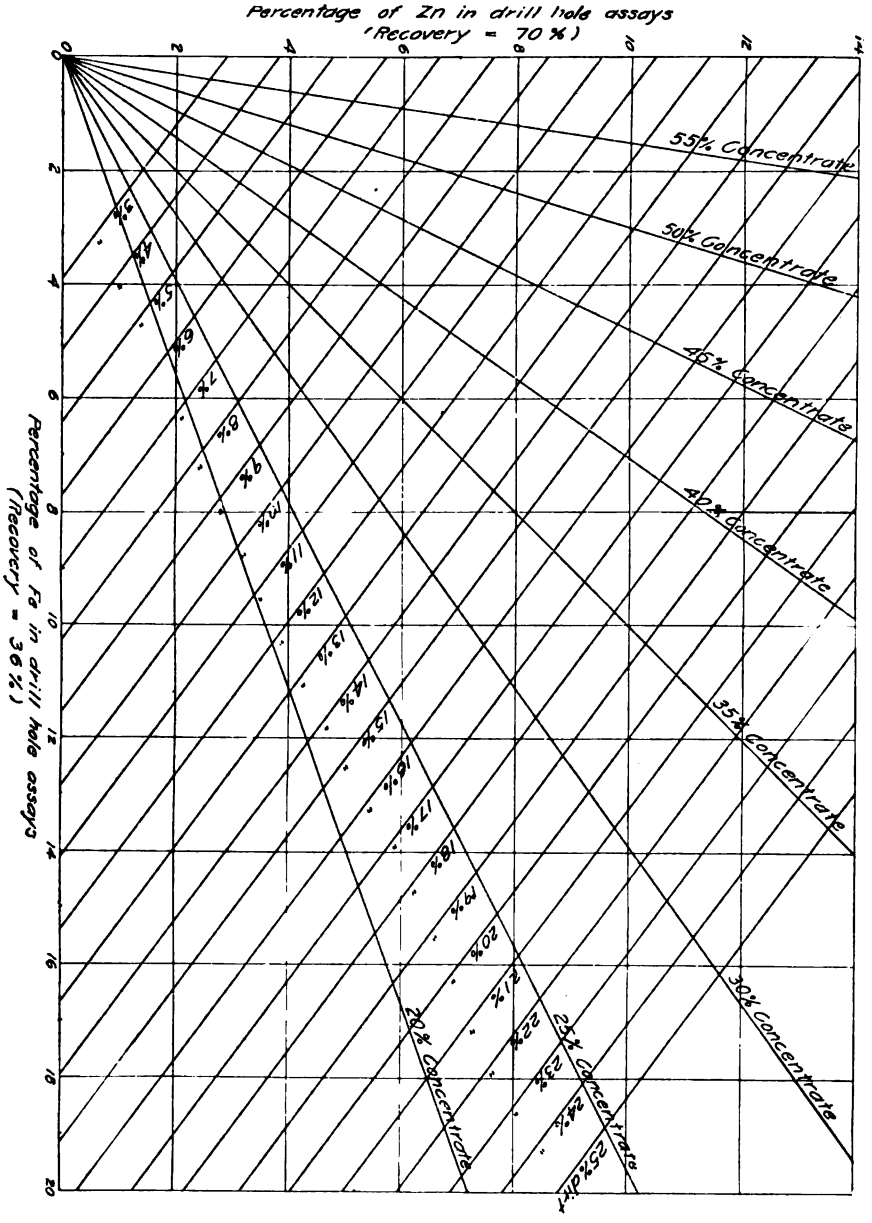
By the same method of procedure, the values obtained are as follows:
Grade of dirt: 14.3 per cent.
Grade of concentrates, 40.7 per cent.

There is adequate difference between these two sets of figures to allow for a considerable variation in any appraisal based on the values of the profits to be derived from mining the ore body.

Sufficient mining has not been done in the district on well drilled ore bodies to admit of the determination of a reliable set of average factors for mill recoveries, etc. It is doubtful if such a set of factors will ever be derived, for the recovery of the sulphides depends too much on the varied nature of their occurrence, and on the character and efficiency of the methods of concentration. One or two rather striking checks have been made, but these appear to be exceptional.

G. Determination of Ore Prices.

Prices of zinc concentrates are founded on the Joplin base, which is the price of 60 per cent concentrates, East St. Louis delivery. For the Wisconsin field, which produces much lower grade concentrates than Missouri, convenient bases such as the prices of 25, 35, 45 per cent ore on a certain spelter market are used. These prices vary up and down with the price of spelter, and the price of 60 per cent concentrates per ton is roughly 7 or 8 times that of spelter per hundred weight. The price of ore varying in zinc content from, say, 30 to 40 per cent is de-


Percentage of Zn in drill hole assays
(Recovery = 70 %)
0
2
4
6
8
10
12
14
16
18
20
Percentage of Fe in drill hole assays
(Recovery = 36 %)
55% Concentrate
50% Concentrate
45% Concentrate
40% Concentrate
35% Concentrate
30% Concentrate
29% Concentrate
25% Concentrate
25% Ash
4%
5%
6%
7%
8%
9%
10%
11%
12%
13%
14%
15%
16%
17%
18%
19%
20%
21%
22%
23%
24%

rived from the 35 per cent base price. For every unit of zinc content above or below 35 per cent, the price varies up or down between 60 and 70 cents. For every one cent rise or fall in the price of a hundred weight of spelter, the price of ore rises or falls between 4 and 5 cents. Thus far, prices of certain grades of ore to be derived from an estimated ore reserve, may be fairly well approximated. There are other important factors, however, influencing the price of zinc ore, which cannot be taken into consideration before the ore is mined and ready to be marketed These are: (1) the effect of the law of supply and demand; (2) the desire for certain types of ore, on the part of the different ore buyers; (3) the percentages of lead and lime in the concentrates, which give rise to penalties; (4) chemical characteristics of the black jack itself, and especially the intimacy of association of the zinc with the iron contained therein, etc.

The result of the operation of the above variables is that a certain 35 per cent zinc ore may be worth say $13.65 to one buyer on a $5.15 spelter market, while *another* 35 per cent zinc ore may sell for $16.60 or more to another buyer on the same market. This is a considerable, but not an uncommon, variation. Such variations cannot be reckoned with in determining the value of zinc concentrates estimated from drill hole assays, which determine only zinc, iron and lead.

Other factors that increase the difficulty of predicting prices of zinc ore are, (1) the availability of foreign supply, (2) new tariff duties, and (3) increased demand for ore due to such unforeseen contingencies as the present European war.

A more or less similar discussion is applicable to lead concentrates, which are sold on the basis of the price of 80 per cent lead concentrates at St. Louis. The occurrence of galena is so irregular in association with the jack that the tonnage of lead concentrates to be derived from a well-drilled ore-body cannot even be guessed. Lead concentrates afford a considerable element of value in any ore body, but this element is almost impossible of determination from drill hole assays. It is rather interesting, however, in this connection to note that during each of the past five years the ratio of lead to zinc concentrates for the whole district [22] has remained remarkably uniform, varying from 1.83 per cent to 2.02 per cent, the average for the five years being 1.91 per cent. In the mines included in making up the composite for the "hypothetical zinc mine", this ratio varies from 0.9 to 3.9 per cent, with an average of 2.2 per cent. On this basis and on that of past production at the particular mine only, can an estimate of the future production of lead concentrates be made.

[22] These small numbers refer to the bibliography in the back of this volume.

CHAPTER III. "THE HYPOTHETICAL ZINC MINE"—THE BASIS OF THE SUBSEQUENT DISCUSSION.

Through the kindness of the Vinegar Hill Zinc Co., the Mineral Point Zinc Co., the Wisconsin Zinc Co., the Cleveland Mining Co., and the Field Mining & Milling Co., complete cost and production details of the following properties were made available to the writer for the purpose of constructing therefrom an average life history of one of the larger zinc mines, for illustration in the present study. Other companies also kindly volunteered their data, but owing to the lack of a few rather important details, it was considered inadvisable to include their mines in the composite. The following mines have been included:

Vinegar Hill Mine, Day's Siding, Illinois.
Ellsworth-Rundell Mine, Livingston, Wisconsin .
Kennedy Mine, Hazel Green, Wisconsin.
Fox Mine, Strawbridge, Wisconsin.
East End Mine, Platteville, Wisconsin.
Winskell Mine, New Diggings, Wisconsin.
Cleveland Mine, Hazel Green, Wisconsin.
Crawhall Mine, New Diggings, Wisconsin.

From the data thus available, the figures appearing in Column I, Table I, have been obtained. The figures for annual tonnage of dirt hoisted, grades of dirt and concentrates, and costs per ton of dirt and per ton of concentrates, represent the weighted averages for all the eight mines taken together.

In Columns II to V, this set of figures is split up over a period of four years in such a way that the weighted averages for the four years are equivalent to the figures of Column I. The average annual spelter prices are assumed, and on them and on information obtained in the district, the prices of the various grades of zinc ore are based.

TABLE I.

Item	I 4 years weighted average	II 1st year average figures	III 2nd year average figures	IV 3rd year average figures	V 4th year average figures
Tons dirt hoisted (total)	300,000	.....	.....	.....	.....
Tons dirt hoisted (per year)	75,000	60,000	70,000	80,000	90,000
Grade of dirt	8.62	10.25	8.50	8.20	8.00
Percentage ratio, PbS to total conc	1.96	1.96	1.96	1.96	1.96
Tons ZnS concentrates	25,352.4	6,030	5,833	6,431.4	7,059
Tons PbS concentrates	506.6	120	117	128.6	141
Grade ZnS concentrates	38.7	42.5	44.0	38.4	31.3
Price of spelter	.....	5.70	5.40	5.00	5.50
Sale price of ZnS concentrates	.....	$24.27	$24.10	$17.90	$15.50
Sale price of PbS concentrates	.....	$56.00	$51.00	$46.25	$51.80
Operating cost* per ton of dirt	$1.266	$1.350	$1.300	$1.260	$1.190
Operating cost per ton of conc	$14.70	.....	.....	.....	.....
Cost of preliminary exploration, sinking, development and equipment	$30,000	.....	.....	.....	.....
Salvage value of equipment	$1,500	.....	.....	.....	.....

* Operating cost signifies the actual mining, milling and other expense essential to getting the ore ready for the market. No charges are included for interest, royalty or amortization.

The data in Table I have been recast into a series of annual totals for receipts, costs, and profits, as given in Table II.

TABLE II.

Year.	I Gross receipts	II Royalty (10%)	III Cost, including charge for amortization of capital invested ($23,500)‡	IV Net profits,* Col. I–Col. III	V Cost, no amortization charge included	VI Operating† profits, Col. I–Col. IV
1	$159,200	$15,920	$87,710	$65,490	$81,000	$72,200
2	146,570	14,657	97,710	48,860	91,000	55,570
3	121,050	12,105	107,510	13,540	100,800	20,250
4	116,570	11,657	113,810	2,760	107,100	9,470

* See Part II, Chapter III, page 47, for method of determination.
† Operating profits are the difference between receipts and operating cost, as the latter is defined in the footnote below Table I above.
‡See page 47.

CHAPTER IV: THE SIGNIFICANCE OF THE TERM "FULL CASH VALUE", OR "RATIONAL VALUATION", FROM THE POINT OF VIEW OF THE GENERAL PROPERTY SYSTEM OF TAXATION.

The laws of Wisconsin state that all mineral-bearing lands shall be annually assessed at the "full cash value which could be obtained therefor at private sale" (Part I, Chapter II, A). This "full cash value" is understood to mean a sum of money which engineers and business men would be willing to pay for a property if they should have full knowledge of all the facts of past production and future prospects at their command. The general property system, which for the purpose of this study is the standard, values each property as a unit, irrespective of division of ownership, so that any valuation given to a property, as an assessment, should represent the whole value of that property alone.

Unless it is desired that mining property should escape part of its share of the tax burden, as it is distributed under existing conditions, any system of assessment or taxation that might be applied to mining property, in substitution for the general property system, should give results that would compare favorably with those obtained from a thorough application of general property principles. That is to say, any alternative method should yield approximately the same revenue as the general property system, when that system is annually applied to a series of valuations which represent the "full cash value at private sale".

It is important, therefore, at this point in the discussion to ascertain just what are the factors that determine "full cash value". It is accepted as a general principle that the value of a property to a prospective purchaser depends on the present worth of all the profits that he would derive therefrom. Consequently the immediate problem is to analyze the matter of profits, and to find out just what items on a well-kept cost sheet are legitimate charges from the point of view of profits to a prospective buyer. After this is determined, the principles laid down will be used in arriving at figures representing the "full cash value" of the "hypothetical zinc mine". These amounts will represent the standard assessed valuations against which to measure the results from all other methods of valuation and taxation (See Part II).

Such standard valuations will be frequently described in the sequel as "rational valuations".

The chief items on a well- kept cost sheet for the zinc and lead mines would be listed somewhat as follows:

Item	Total Cost	Cost per ton dirt	Cost per ton concentrates
Mining	$.....	$.....	$.....
Milling	.....	.....	.....
Power	.....	.....	.....
Prospecting	.....	.....	.....
General	.....	.....	.....
Overhead	.....	.....	.....
Taxes	.....	.....	.....
Insurance	.....	.....	.....
*Interest	.....	.....	.....
Administration	.....	.....	.....
Miscellaneous	.....	.....	.....
Maintenance and repairs	.....	.....	.....
*Depreciation	.....	.....	.....
*Amortization of investment	.....	.....	.....
*Royalty	.....	.....	.....

(*not included in "operating cost".)

While all of the above items are legitimate and necessary costs from the point of view of an operating company, nevertheless *from the view point of the sale value, which is that of the general property system of taxation,* those items marked with an asterisk (*), do not constitute an inherent part of the cost of production.

This statement may be made clearer by an illustration. As stated in Part I, Chaper II, A, according to the law mineral-bearing lands are assessed as units, no allowance being made for division of ownership. The sale value of a piece of mineral property to be assessed is the whole value of that property, and includes the interest of all those parties concerned with the enterprise. A prospective purchaser therefore would consider what he could afford to pay for the combined interests of the fee owner, operating company and capitalist or banker. From this point of view, therefore, it may be seen that such items as royalty, interest, amortization and depreciation are in essence deductions from profits. *The two points of view emphasized above should be kept distinct, as on them depends the interpretation of the following more detailed discussion.*

A. Royalty, and Interest on Investment.

Since the general property system values a property as a unit irrespective of division of ownership, the entrepeneur, who operates the mine, the land owner, who provides the raw material, and the capitalist or banker, who provides the capital, become in essence owners to the

extent of their interest in the enterprise. Royalty and interest can only be considered as deductions from profits from the point of view of the entrepeneur, just as net earnings and royalty may be considered as deductions from profits from the point of view of the capitalist, and just as net earnings and interest may be considered as similar deductions from the point of view of the fee owner.

A few extracts from a paper by A. Lowes Dickinson[6] will make these points clear:

"Accountants frequently have to give opinions as to the propriety of including rent and interest in costs. In theory these two items are identical, rent being the sum paid to a capitalist for the use of land or buildings, and interest being his compensation for placing his natural product or his accumulated savings at the disposal of the manufacturer. Both items are therefore in the nature of a division of profits, out of which alone they can be met, and they should therefore be strictly excluded from costs. In practice, however, the effect of the laws of supply and demand is such that one capitalist is frequently able, as has been shown, to compound with another capitalist for his share of profits and to obtain instead a fixed payment independent of what ultimate profits may be. This fact seems, however, hardly to justify the treatment of these items as cost, but rather that they should be treated as an advance by one capitalist to another of a proportion of the profits which the former *expects* to realize, this proportion being accepted in full settlement of a fluctuating and doubtful future sum".

"If two manufacturers have identical facilities for manufacturing the same article and adopt the same methods and at the same expense, it is certainly not reasonable to say that the manufacturing cost of the one who rents his facilities instead of owing them is higher than that of the other who owns them; but it is reasonable and correct to say that the former, who has a smaller personal investment, is sharing his profits with the capitalist who contributes the facilities."

"Similarly, in the case of interest, the manner in which capital is provided cannot affect cost of manufacture."

"Some confusion in relation to these two items of rent and interest is found in the relation of the profits of a corporation or an individual to the profits of the business which is carried on. The latter should be identical under the same conditions of manufacture, whatever the financial arrangements may be, but the former is affected materially by the share of such profits which is distributed to others in the shape of rent and interest as well as in commission or other payments dependent in any way upon profits."

"The more I consider the subject the more I incline to the conclusion that in practice at any rate interest and rent (so far as the latter represents a payment for the use of land and buildings and not any charge for other services) could only be considered as a division of profit, and that the adoption of any other principle must lead to injustice and error. This may be emphasized by referring to the Tariff commission, whose duty is to inquire into the cost of manufacture of various articles in this country as compared with similar articles abroad. While the propriety of an import duty to offset the increased cost of production in this country might be justifiable, it would be very hard indeed to justify an import duty for the purpose of enabling manufacturers and others to continue to earn the much higher rates of interest and profit which prevail here."

B. Amortization of Capital Investment.

Capital investment is understood to mean the actual sums of money invested in a mining property, in the way of purchase price; exploration and development before the commencement of mining operations; shaft sinking; plant and equipment. Expenditures for the erection of additional equipment, rather than for the replacement of the old, are also included. Prospecting and development costs, incurred during the period of actual operations, are chargeable to cost of mining.

1. *Methods.*

Cost sheets usually contain an item for the recovery of capital invested. Several methods are used to take account of this factor. (a) In some cases, no profits or dividends are declared until the full amount of initial investment is returned. Subsequent earnings therefore become pure profit. (b) Some companies charge off a definite percentage of the investment each year (15 or 20 per cent per year is common in the zinc and lead district). (c) Other companies divide the total investment by the estimated tonnage of ore developed, and hence make a definite charge on every ton of dirt.

None of the above methods is strictly logical. The earnings of a company which is working on a wasting asset, such as an ore body, are composed partly of principal invested, and partly of profit on that principal. At the end of the period of life, or when an ore body is exhausted, the operating company should have recovered the exact amount of its original investment plus a certain profit on that investment. Consequently some method should be devised whereby the amount of money laid aside and invested during operation for the recovery of capital, should at the end of the period of life amount at compound interest to

the original principal. It may be readily seen that by the methods described under (a) and (c) above, the sums set aside and invested either at the beginning or during life, will amount at the end of life to considerably more than the original investment.

The only reasonable manner of attaining the desired result is by the method of laying aside and investing equal annual instalments. This method has been used by J. R. Finlay[1] and E. B. Skinner[7]. The formula for the annual instalment given by the latter authority is

$$Y = k\left(\frac{i}{(1+i)^n - 1}\right) \qquad \text{(M)}$$

where Y = annual instalment required
k = principal invested and to be recovered
n = life of wasting asset in years
i = rate of interest on invested instalments

The formula is obtained as follows:
Y, invested at the end of each year at compound interest for n years amounts to k, thus:

$$k = Y(1+i)^{n-1} + Y(1+i)^{n-2} + \ldots\ldots + Y$$

whence the expression (M) for the value of Y is deduced.

If it could be determined in advance just what the operating profits were going to be, it might be more reasonable to set aside and invest a definite percentage of these profits each year during the life of the mine. In the absence of such information, the method described seems to be the only practicable one.

2. *Amortization of Purchase Price in Its Relation to Valuations.*

At the expense of constant repetition, it must be emphasized again that the point of view of the general property system with regard to the assessment of mining property is that of an intending purchaser. In determining what he could afford to pay for a property (that is, the sale value), he would not concern himself about the amount of money the present owners paid for the property. They might have paid twice as much, or only half as much, as the property was worth. That fact would not affect the intending buyer's estimate of the value of the property to him. This point has been frequently and vividly illustrated by citing an example of two mines, exactly similar in all respects, but owned by two different companies. One of the companies paid, say, $100,000 for its mine, while the other company simply leased some

ground and discovered its own mine. From the point of view of an intending purchaser, the two mines are equally valuable. The only value, that the past records of an operating company have to a prospective buyer, is that of giving him some conception of what return he may expect from the property in the future.

Consequently, a charge for "amortization of purchase price" (or "ore exhaustion") has no legitimate place as a cost, in the determination of sale price valuations.

3. *Depreciation of plant and equipment and amortization of capital spent on exploration and development in their relation to valuatons.*

a. The case of a going concern.

Following a similar course of reasoning to that outlined under 2 above, a prospective purchaser of a property is not especially interested in what the present company has rightly or wrongly spent on exploration, development, equipment, etc. What he is keenly interested in, is the net return he may expect to get out of the property under existing conditions. This situation, and that described under 2 above, may be clearly illustrated by reference to the "hypothetical zinc mine", pages 18 and 19. During the first year of life the operating cost* averages $1.350 per ton of dirt. This item represents the actual cost of mining, milling and further treating the ore till it is ready for sale. In other words, it represents what it would cost a second and entirely disinterested party, with the present equipment and administration, to completely treat one ton of dirt. That is to say, this figure of $1.350 entirely disregards or excludes any charge for indebtedness on the property. It consequently takes no account of depreciation or amortization or interest. In the same example, the receipts per ton of dirt for the first year amount to $2.552 per ton dirt. The difference between this amount and the operating cost is $1.202 and is here called the "operating profit" per ton dirt. If a purchaser should take the property off the hands of the present owners, with the existing equipment and administration, and clear of indebtedness, this amount of $1.202 is the net return he would derive from the operation of the mine.

Consequently, the amount of money he could afford to pay for the property would be a sum equal to the present worth, at a fair rate of interest, of all the operating profits which he would with reasonable certainty get from operation during the life of the mine.

This is exactly the point of view adopted by any mining company in

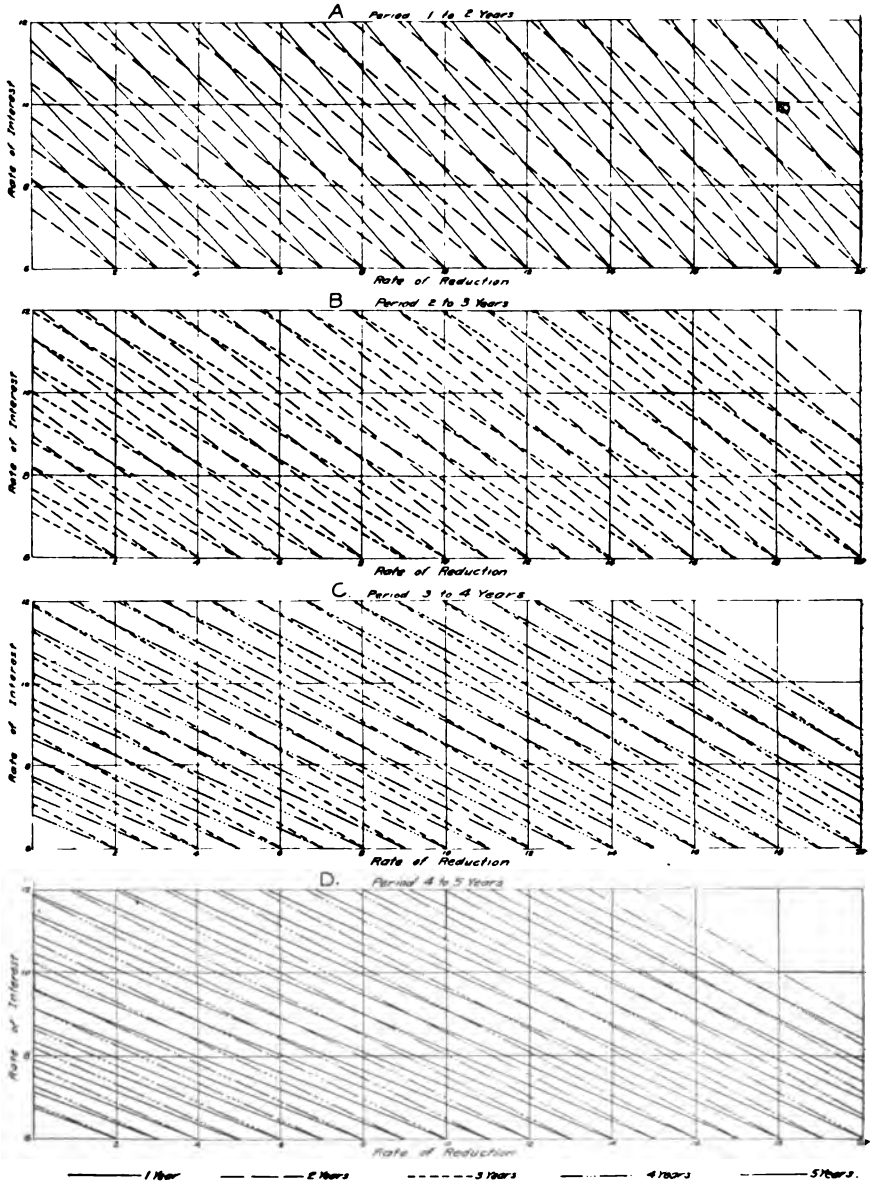
*See page nineteen (Table I) foot note.

valuing a property which it intends to purchase. If the mine which is under consideration is fully equipped, the intending purchasers estimate the amount of money they would receive from sales of ore, and the amount of money it would cost to keep the mine in operation. The difference is profit, and is the basis of what the company could afford to pay.

Another method of arriving at the same conclusion would be from the point of view of the present owners of a property. After all the expenses of operation are provided for, a certain sum may be assumed to remain, called operating profit. In the case above cited, this sum is $1.202 per ton dirt. On this sum, the present owners (that is the company which operates the business, the fee owner who furnished the land and mineral rights, and the banker or capitalist who advanced the money necessary for the carrying on of operations) find it necessary to invest a certain amount calculated to return to them the original investment. What remains is net earnings, and is subdivided into profit to the company, royalty to the fee owner, and interest to the banker. It certainly seems logical to think that the owners would not sell the property for a sum equal to the present value of these net earnings. A selling price would include the present value of the net earnings plus the principal they still have invested in the business. Both of these items are met out of the operating profit. Consequently, from their point of view as well, the value of the property is the present worth of "operating" rather than "net" profit.

b. The case of a prospect, sufficiently drilled to warrant mining operations.

The drill holes on such a property are assumed to outline a certain ore body and give an estimate of gross receipts. From a consideration of all data, an intending purchaser estimates a certain return in the way of operating profit which would have a definite present value. He also estimates the principal he will have to invest in equipment and development before mining operations can begin. The difference between these two estimates is the sum he would be willing to pay for the property. The buyer would have no especial interest in the money already spent on drilling—all he is concerned about is the tonnage, grade and value of ore drilled out, and the probable cost of getting it to the market. The company that did the drilling might have put down 60 holes, of which only 25 were in ore, or it might have put down 30 holes, of which 25 were in ore. If the ore body outlined were the same in both cases, the difference in cost in the two instances would not influence the value of the property.


A Period 1 to 2 Years
Rate of Interest
Rate of Reduction
B Period 2 to 3 Years
Rate of Interest
Rate of Reduction
C. Period 3 to 4 Years
Rate of Interest
Rate of Reduction
D. Period 4 to 5 Years
Rate of Interest
Rate of Reduction
1 Year
2 Years
3 Years
4 Years
5 Years.

C. Rate of Interest, or Adequate Return on Mining Investment.

The "full cash value" or "rational valuation" of a mining property is described as the present value of future profits. Consequently, an important factor to be considered in arriving at such a result, is the rate of interest at which future profits are to be discounted. The rate of interest used should be in some manner a function of the risks of the business. It is not proposed to go into any detail here in the discussion of this matter. Treatments of the subject may be found in almost all the references on mine valuation given in the appended bibliography.

In determining the "full cash value" or "rational valuation" of a mining property from future profits, the risks inherent in the mining business must be taken into account. There are two methods of accomplishing this result. The first is the allowance of a high rate of interest, say 10 per cent or above. The second is the use of an ordinary interest rate combined with conservative factors and liberal reductions, throughout the calculation of sale value. It is a somewhat common practice to use a 6 per cent rate of interest, and a 10 per cent reduction from the valuation thereby obtained.

In Plate III, there is shown in graphic form the relations, as far as actual results are concerned, between various combinations of rate of interest and rate of reduction. As explained in the title, these diagrams all translate a 6 per cent interest rate and various percentage reductions into terms of different interest rates combined with different reduction rates. The top diagram (A) refers only to a period of residual life up to and including 2 years. The full lines refer to periods of one year, the broken lines to periods of life of 2 years. By interpolation, values may be obtained for periods of life between 1 and 2 years. The full line running upwards and to the left from any point (say 10) on the bottom line, gives several combinations of interest and reduction rates that will produce the same result as the 6 per cent interest and 10 per cent reduction.

Suppose for instance, the future profits of a mine whose residual life is 1 year, are M dollars. The present vale of these profits at 6 per cent interest, and with a reduction for hazard of 10 per cent would be $\frac{M}{1.06} \times \frac{90}{1\ 0}$ dollars. It is required to find how much percentage reduction would have to be made to get this same result using a 10 per cent interest rate. Follow up the diagonal (full) line from 10 until the intersection with the horizontal line representing 10 per cent

interest be reached. Drop a line perpendicularly from here to the bottom line of the diagram. The point at which this bottom line is cut gives the rate required. In the case cited, the value is 6.58 per cent.

$$\text{Consequently } \frac{M}{1.06} \times \frac{90}{100} = \frac{M}{1.10} \times \frac{100-6.58}{100}$$

If the period of life were 3 years instead of 1, and the other data the same, the quantity required would be obtained from either the second (B) or third (C) diagram, using the dotted line. The result would be 3.26 per cent.

The curves for 2, 3 and 4 years are repeated on the last three diagrams so as to allow for interpolation.

A study of the diagrams shows the following interesting results. The factors, 6 per cent interest and 10 per cent reduction, correspond to the following combinations of a 10 per cent interest rate and various rates of reduction.

Life of mine			Equivalent	Combination
1 year	10%	interest and	6.58%	reduction
2 "	10%	" "	4.87%	"
3 "	10%	" "	3.26%	"
4 "	10%	" "	1.60%	"
5 "	10%	" "	0.00%	"

For short lived mines at least, these factors should take account of all hazards. In spite of the fact that a prospective purchaser would use a high legree of conservatism in the selection of the factors used in arriving at the sale value of a mining property, and considers that thereby the risks to be encountered during operation are no greater than those in any other kind of business, it is nevertheless true that banks do not lend money to a mining business at the same rate as to other industrial or commercial enterprises.

D. Individual Versus Average Mine Costs.

The question has arisen as to whether it is correct to base the valuation of a mining property on the actual costs as shown by the records of the operating company. The value that the general property system aims to place upon a property is the "full value thereof at private sale"—that is, the value to a prospective purchaser. It is common sense to maintain that the value of a property to anybody is based not so much on the probable costs as they will be incurred by the sellers, as on the probable costs as they will be incurred by the buyers.

In a logical analysis this item of cost resolves itself into two parts—

that which is due to advantage or disadvantage of natural conditions, and that which is due to the efficiency or inefficiency of the present operators. It seems reasonable, therefore, that the cost figure a prospective buyer would use on which to base a valuation would take full account of the former feature, but would adjust the latter feature to meet in some measure the efficiency he would expect to attain in the operation of the mine. The following quotation is of interest in this connection:

"The plaintiff objects to the Finlay factors because they attempt to give the entire net earnings that may be derived from each mine as that particular mine is being conducted; and that, if the management of one mine is prudent and economical, and the other shiftless and extravagant, the profit of the prudent and economical mine would be larger than the other. But this is true of all property subject to taxation. If we take the case of two farms of equal acreage, soil and fertility, we may find that one farmer will rotate his crops, keep the soil properly fertilized, and use modern and better business methods upon his farm, while the other farmer may be shiftless and raise more weeds than crops. The prudent farmer, by his better business methods, has increased his profits, but he has done so in such a way as to increase the value of his farm.....

"In all these cases of increased earnings and increased profits, the property has become more valuable, would sell for a higher price, and should therefore be valued higher for assessment purposes."[8]

A study of the operating costs per ton of total concentrates for the eight mines used in constructing the composite on which the "hypothetical zinc mine" is based, was made by the writer, and the results have been embodied graphically in Plate IV.

Explanation of the Diagram.

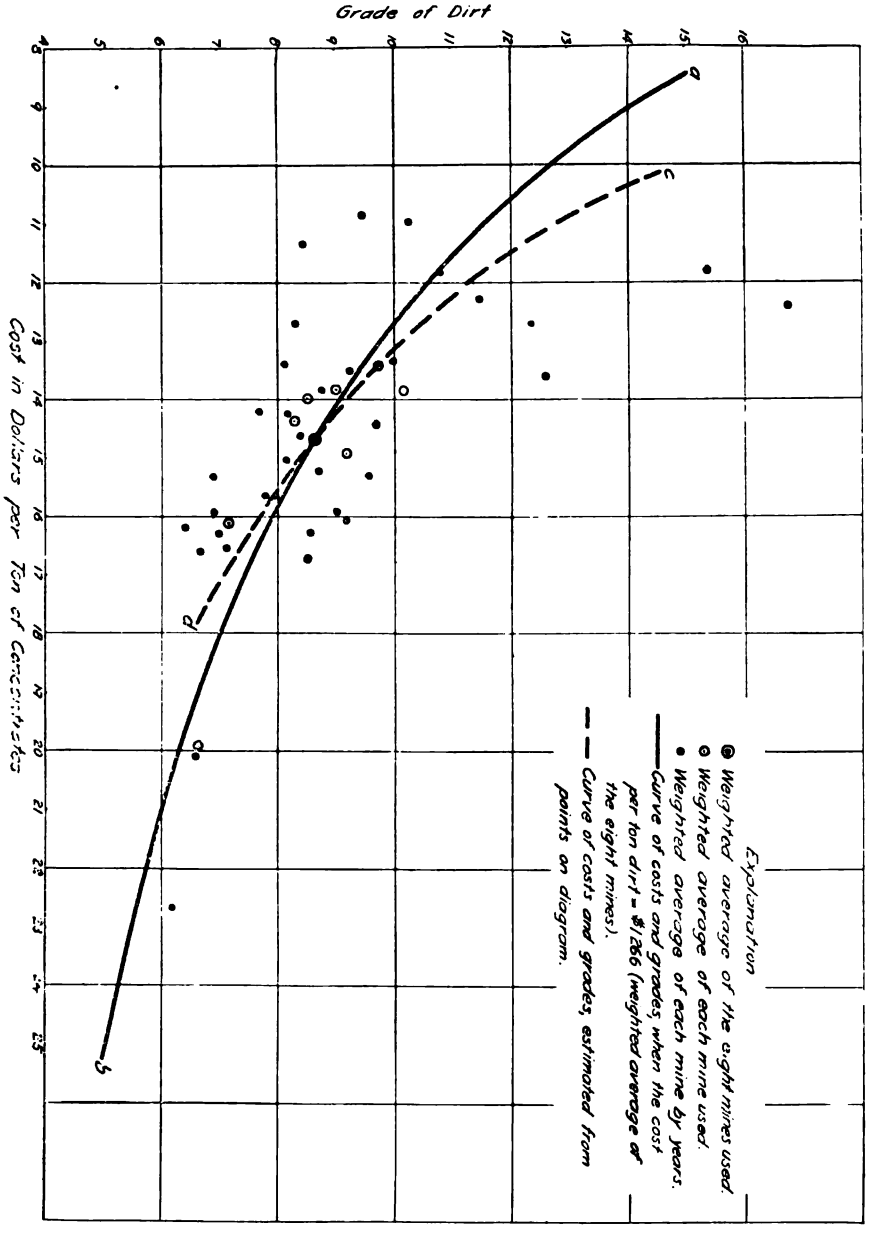
a. The average grade of dirt of each mine studied during the period of life covered by the available records was computed.
b. The average grade was similarly computed for each year of life of each of the same mines.
c. The average grade of dirt and the average cost per ton of total concentrates for all eight mines taken together were computed.

The above results are platted in the diagram, according to the explantation of symbols given in the upper right hand corner.

The average cost per ton of dirt for all eight mines taken together is $1.266. By assuming this value constant, and varying the grades of

dirt, a series of costs per ton of concentrates is obtained, whose values fall along the curve a-b. This curve represents the average cost of producing one ton of concentrates, when the grade of dirt varies from 5 to 15 per cent, on the assumption that the average cost per ton of dirt remains constant at $1.266. The curve, a-b, however, does not seem to represent an average of the points platted on the diagram. The curve, c-d, seems more closely to represent this average. The difference between the two curves is due to the added cost per ton of dirt of treating high grade dirt (on account of extra tonnage of concentrates) as compared with low grade dirt. For this reason the actual curve, c-d, falls above the theoretical curve when the dirt is above 8.62 per cent (the average) and below it, when the dirt is less than the average.

The wide variance in the position of the points, and their dependence on the grade of the dirt to be mined shows the difficulty of endeavoring to estimate a figure for cost per ton of dirt that would take account of natural advantages and disadvantages, combined with an average efficiency of operation and administration. For the present purpose, therefore, it is considered advisable to use the actual costs of the mine to be valued.


Grade of Dirt
Cost in Dollars per Ton of Concentrates
Explanation
Weighted average of the eight mines used.
Weighted average of each mine by years.
Curve of costs and grades, when the cost per ton dirt = $1.286 (weighted average of the eight mines).
Curve of costs and grades, estimated from points on diagram.
a
b
c
d

Part II: Methods of Valuation and Assessment.

The second part of this paper consists essentially of a treatment of various methods of mine valuation and assessment. In Chapter I, a general description of the standard against which to measure other systems is given. This is that method which determines annually the "full cash value" or "rational valuation" of the mine, from the point of view of the general property system, in accordance with the principles discussed in Part I, Chapter IV. Chapters II to VI take up a discussion of methods used in several of the states and provinces of United States and Canada. In Chapter VII, there is suggested a new system of assessment that is believed to be applicable to the zinc district, and to give on the whole results approximately equivalent to those of the general property system. All of the methods are compared with the standard of Chapter I, by their application to the "hypothetical zinc mine".

No attempt is made to defend the general property system as a basis of taxation for mining property.

CHAPTER I: THE STANDARD AD VALOREM METHOD.

As shown in Part I, Chapter IV, the standard method assesses a mining property annually at its "full cash value". This "full cash value" is described as being the present worth, at a certain rate of interest, of the operating profits of a mine. In the present chapter, the "rational valuations" of the "hypothetical zinc mine" are determined, and become the basis for future discussion and comparison.

It is assumed that the whole history of the "hypothetical zinc mine" is known in advance. The valuations are considered as being determined at the beginning of each year, and the profits as being declared at the end of each year. Interest is reckoned at 6 per cent. The an-

nual operating profits, as given in Table II, page nineteen, are as follows:

1st year	$72,200
2nd "	55,570
3rd "	20,250
4th "	9,470

The annual "rational valuations" are as follows:

1. *Beginning of the 1st year.*
   Valuation:

$$\frac{72,200}{1.06} + \frac{55,570}{1.06^2} + \frac{20,250}{1.06^3} + \frac{9,470}{1.06^4} = \$142,100$$

2. *Beginning of the 2nd year.*
   Valuation:

$$\frac{55,570}{1.06} + \frac{20,250}{1.06^2} + \frac{9,470}{1.06^3} = \$78,385$$

3. *Beginning of the 3rd year.*
   Valuation:

$$\frac{20,250}{1.06} + \frac{9,470}{1.06^2} = \$27,525$$

4. *Beginning of the 4th year.*
   Valuation:

$$\frac{9,470}{1.06} = \$8,930$$

5. In order to compare the results of the application of other methods of valuation and assessment to the "hypothetical zinc mine", a common basis must be agreed upon. This is taken to be the present value at the beginning of the first year of all four valuations or assessments.

Hence, the present value of all the above valuations at the beginning of the 1st year is obtained as follows:

$$\$142,100 + \frac{\$78,385}{1.06} + \frac{\$27,525}{1.06^2} + \frac{\$8,930}{1.06^3} = \$248,050$$

CHAPTER II: THE FINLAY AD VALOREM METHOD.

A. General Description.

The essence of the Finlay method is the determination of an average annual profit to be derived from the operation of a mine during an estimated period of life, and the reduction of the same to its present value, according to a system which annually sets aside for reinvestment that sum which at the end of the estimated period of life, will amount to that present value. The chief factors to be considered in any such determination are, according to J. R. Finlay:[1]

1. The average cost of securing the products of a mine,
2. The average price at which these products can be sold,
3. The rate of production of the mine,
4. The time for which that output can be maintained,
5. The rates of interest to be allowed.

From a knowledge of these details, a probable future average annual profit may be computed. In the words of J. R. Finlay, the present value of these profits is determined as follows:

"The future value of a series of dividends is reduced to a present value by the annuity method; that is, a sum is calculated upon which the series of dividends will pay —— per cent interest and also provide each year a sinking fund instalment which, invested each year at 4% interest, and added to prior instalments similarly invested and reinvested, will equal the sum taken."[2] A table of factors for determining such present values is given in Finlay's "Cost of Mining," page 46.[3] This table is represented graphically in Plate XI, at the end of this treatise.

Fuller descriptions of the procedure adopted by the Finlay system may be found by reference to Nos. 1, 2, 3, 5, 46, in the bibliography at the end. A rather complete discussion of the Finlay method of appraisal as used by the Michigan Tax Commission in connection with iron mines, has just been published by R. C. Allen, State Geologist of Michigan, in the Engineering and Mining World for September 12, 1914.[46]

B. Valuations of the "Hypothetical Zinc Mine."

In this section two studies of the ore body represented by the "hypothetical zinc mine" are made from the point of view of valuation. In both cases the valuations by the Finlay method are assumed to be based on actual examination of the mine at the beginning of each year, and of records of past production.

1. *With the ore-body well drilled at the outset.*

In this case, the drill holes outline fairly well the extent of the ore body. The cuttings are assumed to have been assayed, so that estimates of future production can at all times be made. The average future price of spelter is estimated at the beginning of each year, and the price of the estimated grades of zinc concentrates is based largely on this. It should be noted that the estimated ore reserve is less than the actual reserve, as the latter is given in Part I, Chapter III.. Attention is called to the differences between the estimated results given herewith and the actual results, as shown by Table I, page nineteen. This example may fairly well illustrate the application of the Finlay method to one of the well-conducted mines of the district. Amortization charges are eliminated from the costs, that is, operating profits are the basis of the computations.

(1) *Beginning of the 1st year.*

Data:

Probable grade of dirt	8.75 per cent
Probable grade of ZnS concentrates	42.0 " "
Probable price of spelter	$5.50 per cwt.
No PbS production indicated from assays.	
Price of 42.0 per cent ZnS concentrates on $5.50 spelter market	$22.90
Estimated ore reserve	280,000 tons dirt
Estimated annual hoist	70,000 tons dirt
Estimated life of mine	4 years
Estimated receipts per ton dirt	$2.03
Estimated operating cost per ton dirt	$1.30
Estimated operating profit per ton dirt	$0.73
Estimated annual profit: $0.73 \times 70{,}00$	$51,100
Valuation (using a 6% return on investment and 4 % interest on sinking fund instalments. See table, page 46, Finlany's "Cost of Mining") $= 51{,}100 \times 3.38 \times 0.85^{*} =$	$147,000

(2) *Beginning of the 2nd year.*

The assumptions for the future are based on the results of the first year's production, and on a comparison of them with the drill hole

*NOTE. On account of the absence of data for checking the assumed figures for grades of ore, a 15% reduction from the valuation is made (See Part I, Chapter IV, Section C).

records. On account of the check afforded by the first year's results, only a 10% reduction is made from the calculated valuation.

Data:	Probable grade of dirt	8.30 per cent
	Probable grade of ZnS concentrates	35.0 " "
	Probable price of spelter	$5.25 per cwt.
	Ratio of PbS to total concentrates	1.95 per cent
	Price of 35.0 per cent ZnS concentrates on a $5.25 spelter market	$15.80
	Price of PbS concentrates	$50.00
	Estimated ore reserve	220,000 tons
	Estimated annual hoist	60,000 tons
	Estimated life of mine	3.66 years
	Estimated receipts per ton dirt	$1.367
	Estimated operating cost per ton dirt	$1.35
	Estimated operating profit per ton dirt	$0.017
	Estimated annual profit, 60,000 × 0.017	$1020
	Valuation (for rates, see 1st year), 1020 × 3.18 × 0.90 =	$2875

(3) *Beginning of the 3rd year.*

The following data are based on inspection of past results and future prospects. During the first two years a certain amount of deads, and low and high grade ore, that were not included in the estimates from drill hole data, was mined out. This reduced the grades of dirt and concentrates below what was estimated at the beginning of operation, but also increased the total reserve of dirt.

Data:	Probable grade of dirt	8.25 per cent
	Probable grade of ZnS concentrates	34.0 " "
	Probable price of spelter	$5.25 per cwt.
	Ratio of PbS to total concentrates	1.96 per cent
	Price of 34.0 per cent ZnS concentrates on a $5.25 spelter market	$15.05
	Price of PbS concentrates	$49.00
	Estimated ore reserve	170,000 tons
	Estimated annual hoist	65,000 tons
	Estimated lift of mine	2.62 years
	Estimated receipts per ton dirt	$1.297
	Estimated operating cost per ton dirt	$1.250
	Estimated operating profit per ton dirt	$0.047
	Estimated annual profit, 65,000 × 0.047 =	$3055
	Valuation (for rates. see 1st year), 3055 × 2.315 × 0.90 =	$6470

(4) *Beginning of the 4th year.*

See note under (3) above.

Data:	Probable grade of dirt	8.30 per cent
	Probable grade of ZnS concentrates	33.0 " "
	Probable price of spelter	$5.40 per cwt.
	Ratio of PbS to total concentrates	1.96 per cent

Price of 33.0 per cent ZnS concentrates on a $5.40 spelter market	$16.20
Price of PbS concentrates	$51.00
Estimated ore reserve	90,000 tons
Estimated annual hoist	70,000 tons
Estimated life of mine	1.28 years
Estimated receipts per ton dirt	$1.401
Estimated operating cost per ton dirt	$1.200
Estimated operating profit per ton dirt	$0.201
Estimated annual profit, 70,000 × 0.201 =	$14,070
Valuation (for rates, see 1st year), 14,070 × 1.190 × 0.90 =	$15,075

(5) *Present value of all above valuations at the beginning of the 1st year:*

$$\$147{,}000 + \frac{\$2875}{1.06} + \frac{\$6470}{1.06^2} + \frac{\$15{,}075}{1.06^3} = \$168{,}117$$

2. *With the ore-body poorly drilled at the outset.*

In this case, it is assumed that only 50,000 tons of dirt or crude ore have been blocked out by drilling in advance. A shaft is sunk, equipment installed, and mining operations begun. No further drilling is done, and the ore is simply followed blindly underground. In estimating the ore reserve in this mine, it is assumed as a convention that the ore body continues 200 feet beyond present breasts or beyond the last drill holes in ore. The average cross-sectional area of the ore body is assumed to be 1,200 square feet. The same method of procedure is followed as that used under 1, above. In this case, however, nothing is known about the future probable production after the first 50,000 tons have been taken out. The factors used after that are based entirely on past production, and probable future spelter prices. Amortization charges are entirely eliminated from costs. This example may fairly well illustrate the application of the Finlay method to a mine operating on a large, but poorly explored ore body.

(1) *Beginning of the 1st year.*

Data:	Probable grade of dirt	8.75 per cent
	Probable grade of ZnS concentrates	42.0 " "
	Probable cost per ton dirt	$1.35
	Probable price of spelter	$5.50 per cwt.
	Price of 42.0 per cent ZnS concentrates	$22.90
	Estimated ore reserve: 50,000 + 40,000* =	90,000 tons
	Estimated annual hoist	50,000 tons
	Estimated life of mine	1.8 years
	Estimated profits per ton dirt	$0.68
	Estimated annual profit, 0.68 × 50,000 =	$34,000
	Valuation: 34,000 × 1.640 × 0.88** =	$49,100

* From extension of two breasts 200 feet each.

** 12 per cent reduction factor used to account for hazards.

(2) *Beginning of 2nd year.*

The factors for the future estimates are based exclusively on the average of past production, as no drill hole information exists.

Data:	Probable grade of dirt	10.25 per cent
	Probable grade of ZnS concentrates	42.5 " "
	Probable cost per ton dirt	$1.35
	Probable price of spelter	$5.25 per cwt.
	Ratio of PbS to total concentrates	1.95 per cent
	Price of 42.5 per cent ZnS concentrates on a $5.25 spelter market	$22.00
	Price of PbS concentrates	$50.00
	Estimated ore reserve	40,000 tons
	Estimated annual hoist	60,000 tons
	Estimated life of mine	0.66 year
	Estimated profits per ton dirt	$0.960
	Estimated total profit, $0.960 \times 40{,}00 =$	$38,400
	Valuation: $\frac{38{,}400}{1.04^*} \times 0.88 =$	$32,500

(3) *Beginning of the 3rd year.*

The factors used are based exclusively on the average of past production.

Data:	Probable grade of dirt	9.31 per cent
	Probable grade of ZnS concentrates	43.25 " "
	Probable cost per ton dirt	$1.323
	Probable price of spelter	$5.25 per cwt.
	Ratio of PbS to total concentrates	1.96 per cent
	Price of 43.25 per cent ZnS concentrates	$22.70
	Price of PbS concentrates	$49.00
	Estimated ore reserve	40,000 tons
	Estimated annual hoist	65,000 tons
	Estimated life of mine	0.615 year
	Estimated profit per ton dirt	$0.835
	Estimated total profit: $0.835 \times 40{,}000 =$	$33,400
	Valuation: $\frac{33{,}400}{1.037^{**}} \times 0.88 =$	$28,350

(4) *Beginning of the 4th year.*

The factors used are based exclusively on the average of those of the first three years.

Data:	Probable grade of dirt	8.90 per cent
	Probable grade of ZnS concentrates	41.60 " "
	Probable cost per ton dirt	$1.30
	Probable price of spelter	$5.40 per cwt.
	Ratio of PbS to total concentrates	1.96 per cent
	Price of 41.60 per cent ZnS concentrates	$22.00
	Price of PbS concentrates	$51.00
	Estimated ore reserve	40,000 tons
	Estimated annual hoist	70,000 tons
	Estimated life of mine	0.57 year
	Estimated profit per ton dirt	$0.707
	Estimated total profit, $0.707 \times 40{,}000 =$	$28,280

* $1.04 = (1 + 0.06 \times 0.66)$

** $1.037 = (1 + 0.06 \times 0.615)$

$$\text{Valuation: } \frac{28,280}{1.034^4} \times 0.88 = \$24,060$$

(5) *Present value of all the above valuations at the beginning of the 1st year:*

$$\$49,100 + \frac{\$32,500}{1.06} + \frac{\$28,350}{1.06^2} + \frac{\$24,060}{1.06^3} = \$125,180.$$

C. VARIATION OF THE FINLAY METHOD AS USED IN 1914, IN SOUTHWESTERN WISCONSIN.

After a somewhat careful consideration of the zinc situation, it was decided to use the Finlay principles, as the basis for arriving at the valuations of the mines for assessment purposes. These principles had been applied with fairly satisfactory results to the copper mines of the Keweenawan peninsula, and to the iron mines of northern Wisconsin and Michigan. This system, in its endeavor to obtain sums representing sale value, was believed to check fairly well with the essentials of the general property system.

Schedules of questions asking, among other things, for information concerning exploration, production, receipts, costs and profits from each individual property for the past five years were sent to the various companies in March, and a return was called for in May, including all available data to May 1st. Before and during this period, the writer made a personal examination of every active mine with especial reference to ore reserves, and present production.

As a result of the examination of the properties, mine maps and schedules of information returned by the companies, it was found necessary to make certain changes in the recognized Finlay method, as applied to the iron and copper mines. These changes are summarized below:

1. In properties with a considerable tonnage of ore drilled out and assayed, it was found advisable to base estimates of future grades of ore on this drill hole information, viewed of course in the light of past production; and not to lay too much stress on the grades of ore produced in the past.
2. In the smaller properties which have very little probable ore or ore in sight (and consequently an estimated short life) and no drillings in advance of the workings, the forecast of future

*$1.034 = (1 + 0.06 \times 0.57)$

production was based almost entirely on the production of the past year or fraction thereof, almost regardless of the grades of ore produced previous to that time.

3. At a conference between representatives of the State Geological Survey and the representatives of the mining community, the agreement was reached that it would be reasonably conservative to assume (in the absence of information to the contrary) that each ore body extended 200 feet in advance of each ore breast or the last drill holes in ore, with present dimensions.
4. The average price of spelter was assumed to be $5.15 per cwt. The average price to be expected for ore of any grade (see pages sixteen and seventeen) for purposes of this calculation, was based partly on this spelter market, and partly on the average of a series of ore prices obtained from several operators and ore buyers of the district.
5. The cost per ton of dirt used in the calculation was based in a general way on the average cost obtained from the past records of each individual mine. The appraiser, however, did not hesitate to use a higher or lower figure, if, in his judgment, this was demanded by conditions liable to be met with in the near future. This variation became of considerable importance in the case of mines with a probable life of a year or less.
6. On account of the difficulty of estimating future probable profits in the form of an annuity, and on account of the short lives of the mines, the table of strict present values given by Hurd's Manual[4] (see Plate XII at end) was used instead of the Finlay table.
7. A six per cent rate of interest was used.
8. Reductions varying from 10 to 15 per cent were made from the valuations thereby obtained. The figure used in each case depended on the judgment of the appraiser as to the probable extent of unforeseen risk.

Mining properties were roughly divided into four classes for valuation purposes:

(1) Operating mines, which were making a profit or were likely to make a profit on a $5.15 spelter market.

(2) Mines closed down, but which have ore reserves not likely to be worked at a profit on a $5.15 spelter market.

(3) Prospects with sufficient tonnage of ore drilled out to warrant the undertaking of mining operations.

(4) Prospects with small ore bodies drilled out, not sufficiently large at the time of assessment to ensure the profitable undertaking of mining operations.

Valuations were placed on classes (1) and (3), but not on (2) and (4).

By using this method in such a case as that described under B above, the only changes that would result would be in the valuations made at the beginning of the 3rd and 4th years. Without going into further detail the valuations according to this method are herewith tabulated:

(1) Beginning of 1st year $49,100
(2) " " 2nd " $32,500
(3) " " 3rd " $24,600
(4) " " 4th " $14,420
(5) Present value of all the above valuations at the beginning of the 1st year:

$$\$49{,}100 + \frac{\$32{,}500}{1.06} + \frac{\$24{,}600}{1.06^2} + \frac{\$14{,}420}{1.06^3} = \$108{,}330.$$

D. Criticism of the Finlay Method.

1. *Advantages.*

a. The present value of future profits is the basis on which competent engineers and business men determine the purchase or sale value of a mining property. The following quotation from remarks by C. M. Zander[9] of the Arizona Tax Commission is to the point: "I assume it only proper for any assessing body or any commonwealth to find a valuation on any class of property, in the absence of any better method, in the same way that the people who are involved in that industry and who are handling that class of property, use to find the value themselves."

b. This system attempts to value a mine on the basis of profits from what ore reserve is reasonably certain. If an ore body is very inadequately drilled, and practically no ore is blocked out in advance, any market value which the property would have would be small and almost entirely speculative. This factor is taken into account by the Finlay system in the assumption of ore extension. Even if subsequent drilling should show the ore body to be of great extent and hence very valuable, it would hardly be correct to assume that the Finlay system had overlooked an element of value, in the valuation previously determined. At the time the valuation was made knowledge of the continuance of the ore body did not exist, and the discovery of that continuance gave it added value. (Compare this argument with 2, d below)

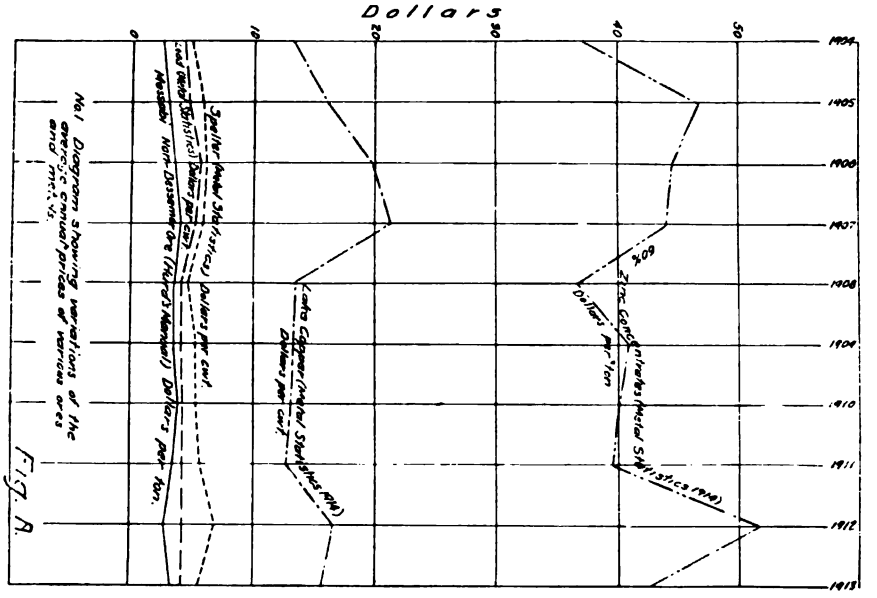

Dollars
0
10
20
30
40
50
1904
1905
1906
1907
1908
1909
1910
1911
1912
1913
Zinc Concentrates Metal Statistics 1914)
Dollars per ton
Lake Copper (Metal Statistics 1914)
Dollars per cent
Messabi Non-Bessemer Ore (Hulst's Handbook) Dollars per ton.
Zinc (Metal Statistics) Dollars per cent
Spelter (Metal Statistics) Dollars per cent
No. 1 Diagram showing variations of the average annual prices of various ores and metals.

Fig. A.

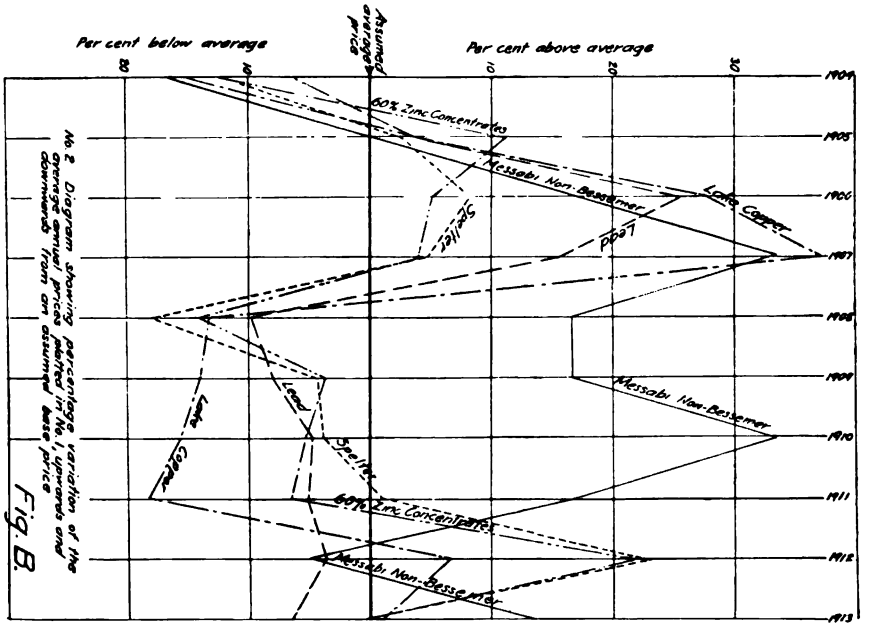

Per cent below average
Per cent above average
Average price
30
10
0
25
50
1904
1905
1906
1907
1908
1909
1910
1911
1912
1913
60% Zinc Concentrates
Messabi Non-Bessemer
Lake Copper
Spelter
Lead
Lake Copper
Lead
Spelter
60% Zinc Concentrates
Messabi Non-Bessemer
No. 2 Diagram showing percentage variation of the average annual prices plotted in No. 1, upward and downward from an assumed base price.

Fig. B.

c. The system applies favorably to ore bodies adequately explored, efficiently operated and with well kept records. In this case only can probable factors for the future be obtained from an examination of past production and advance drill hole information. Hence, the system may be considered to set up a standard of valuation for high class mines, to be used as a basis of comparison in determining the valuations for other mines. In this respect, considerable freedom of judgment is allowed an appraiser in the selection of factors affecting the valuation. For this reason the system lacks the undesirable rigidity possessed by a few of those in use in other states.

d. It discourages the holding of ore bodies in reserve for speculative reasons. (See Plate VI, page 45). Reserve ore bodies are assessed and taxed in the same general manner as operating mines.

2. *Disadvantages and objections.*

a. *It is objected that the prices of zinc ore and spelter are much more variable than those of iron ore and copper.* For this reason, it is urged that the Finlay system cannot be fairly used in southwestern Wisconsin.

A study of the annual price curves of Lake copper, Mesabi non-Bessemer ore, lead, spelter, and 60 per cent zinc concentrates (Joplin base) for the period 1904–1913, was made by the writer in order to investigate the soundness of this contention. The general similarity of the curves is shown in Plate V, figure A. In order to get a better basis for comparison average prices for these different ores and metals were assumed for the period, and percentage annual increases or decreases from these as bases were calculated. The results are platted in Plate V. figure B.

From a consideration of these figures the conclusion is inevitable that the variations in zinc ore and spelter prices when platted on a percentage basis are of the same magnitude as those of iron ore and copper.

b. *It is objected that under any ad valorem system, the fee owner is penalized for having an efficient company mine on his land.* Under the present system of mine assessment in southwestern Wisconsin, the general custom is for the fee owner to pay all real property taxes, in spite of the fact that his only interest in the mining property is his royalty. Royalty is usually 10 per cent of gross receipts, and would be approximately the same in amount regardless of the cost or rapidity of mining. That is to say, if two exactly similar ore bodies were being mined by an efficient and inefficient company respectively, the royalties to the fee owners in both cases would be approximately the

same. On the other hand, the profits, and consequently the assessment, in the former case would be greater than in the latter. The land owner, whose ore body was being mined by the efficient company, would be obliged to pay more taxes than the other land owner, although the benefits each of them derived from the business were about the same. In this respect the fee owner is penalized for having an efficient company mine on his land.

This is really no criticism of the ad valorem method of assessment, but of the general property system under which a mining property is valued at its total earning capacity regardless of the division of earnings between lease holder and fee owner.

c. *It is objected that the general property system subjects a fee owner to double taxation,—once on his income from the mine (royalty), and again on the real value of that from which the income is derived.* This criticism is no doubt correct, but double taxation is not unjust if all individuals in the same class are treated alike.[45] The situation described is identical with that of a farmer, who is taxed, once on the income from his farm, and again on the value of the realty and personalty from which this income is derived.

d. *It is objected that a thoroughly explored ore body pays a larger percentage of its actual earnings, as a general property tax, than one not prospected in advance of present ore breasts.* This is due to the fact that in the first case the probable profits can be roughly estimated for a considerable time in advance and are consequently taxed on each assessing date. In the second case, probable profits cannot be estimated in advance. The result is that a much larger share of the profits escapes taxation here than in the first instance. This fact makes the ratio of the general property tax to actual income in the case of the second ore body lower than in the case of the first. (Compare 1, b page 40.)

e. *It is objected that ad valorem methods assess an ore body that is sufficiently drilled out to warrant the undertaking of mining operations, before any actual mining has taken place.* An ore body may have sufficient reserve to last five years, but for certain valid reasons it may not be worked for two years. The general property system assesses the property seven different times in spite of the fact that the ore will be depleted in five operating years. This is not a criticism of the Finlay method but rather of the general property system of taxation under which all non-productive property is assessed.

f. *It is objected that the Finlay method ascribes a value to a drilled out property, before it has returned any profit; and on the other hand, it does not value a property that is actually losing money, or just*

breaking even, although the fee owner gets his 10 per cent royalty just the same as if the property were making money. In the first case, the fee owner is taxed before he is getting any return from the mine, and in the second case, he is not taxed anything although he may be getting a handsome income in the way of royalty. It is obvious, however, that instances of the second kind would be rare and of short duration.

g. *It is objected that the Finlay system, in basing its valuations entirely on probable profits, decidedly favors mining property when compared with other varieties of real and personal property.* The valuations placed on these other varieties under the general property system have in the great majority of cases no inherent relation to probable profit. The records show that general property assessments are being placed on properties that are continually losing money or just breaking even. (See Part II, Chapter VII, pages 66 to 67). Consequently a share of the tax burden that under the present tax laws belongs to the mining industry is being borne by other industries and other forms of property.

h. *The Finlay method has an important influence on the development and mining of ore reserves.* This influence may be conveniently examined under three sub-headings.

(1) *It is objected that assessments based on the Finlay method put a tax on the development of reserve ore, inactive mines, in advance of present workings, and consequently operate to the detriment of an efficient and progressive company.*

It is quite true that the company which has its ore reserve well drilled out will probably have to pay a greater share of its actual income as taxes, than a company which simply works its ore breasts ahead without any advance exploration. To this extent the Finlay system places a tax on exploration. But in so far as the former company makes good use of its knowledge of reserve ore, by putting in equipment that will properly handle the tonnage, and otherwise decrease costs, just in so far will its profits be greater and more rapidly returned than those of the latter company which has not the knowledge of what lies in advance of present ore breasts.

Consequently the increased present value of the profits to be obtained from scientific exploration will probably in all cases greatly overbalance the increase in taxes due to the same exploration. The conclusion is, therefore, that in medium lived mines, at least, the factor of taxation alone is not great enough to influence noticeably the exploration policy of the operating company.

(2) *It is objected that assessments based on the Finlay method cause rapid mining of the best grades of ore only, so as to reduce the number of assessments and thus lighten the tax burden.*

In order to show that this contention, at least as far as medium lived mines are concerned, is not founded on fact, the following computation, based on the figures given in Part I, Chapter III, for the "hypothetical zinc mine", is introduced.

Example, showing the slight effect, if any, that taxes have on rapidity of exhaustion of an ore reserve:

Total ore reserve	300,000 tons
Total profit, four years	$157,800
Average profit per ton dirt	$0.526

(a) The mine operates for 4 years, with an average annual production of 75,000 tons dirt, at an average annual profit of 0.526x75,000. =$39,450.

Valuation at beginning of 1st year = 39,450 × 3.38* =	$133,300
Valuation at beginning of 2nd year = 39,450 × 2.63* =	$103,700
Valuation at beginning of 3rd year = 39,450 × 1.82* =	$71,800
Valuation at beginning of 4th year = 39,450 × 0.94* =	$37,100

Present value, at the beginning of the 1st year of all the above valuations:

$$\$133{,}300 + \frac{\$103{,}700}{1.06} + \frac{\$71{,}800}{1.06^2} + \frac{\$37{,}100}{1.06^3} = \$326{,}150.$$

Taxes on this amount at 2 per cent = $6,523.00

(b) The mine operates for 3 years with an average annual production of 100,000 tons dirt, at an average annual profit of 0.526x100,000 =$ 52,600

By a similar calculation to the above, the present value at the beginning of the 1st year of all three valuations =$272,600

Taxes on this amount at 2 per cent =$ 5,452.00

(c) The mine operates for 2 years, with an average annual production of 150,000 tons dirt, at an average annual profit of 0.526x150,000 =$ 78,900

Present value at the beginning of the 1st year of the two valuations =$213,650

Taxes on this amount at 2 per cent =$ 4,273.00

(d) The mine operates for 1 year, with a production of 300,000 tons dirt, at a profit of $157,800.

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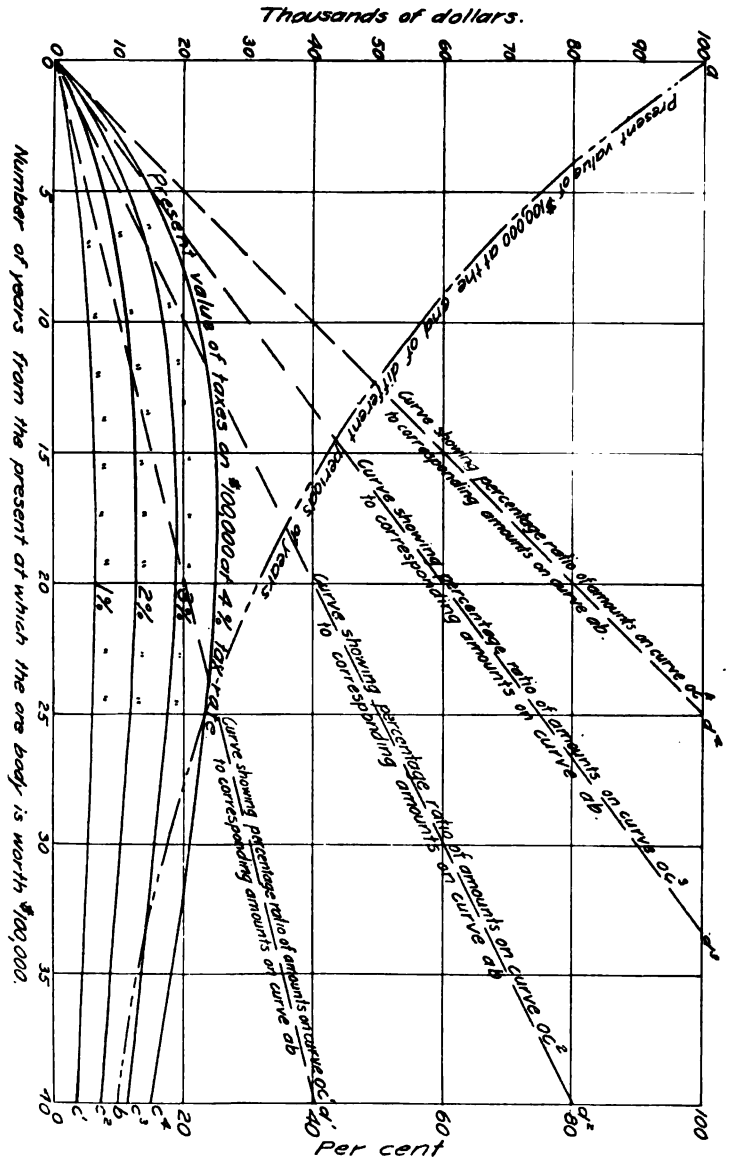
* Present value of an annual dividend over 4, 3, 2 and 1 years at 6 per cent, and replacing capital by reinvestment of an annual sum at 4 per cent. See Finlay "Cost of Mining". (Plate XI, at end of this paper.)


Thousands of dollars.
Present value of $100,000 at the end of different periods.
Curve showing percentage ratio of amounts on curve ab.
Curve showing percentage ratio of amounts on curve ab.
Curve showing percentage ratio of amounts on curve ab.
Curve showing percentage ratio of amounts on curve ab.
Present value of taxes on $100,000 at 4% tax-rate
Curve showing percentage ratio of amounts on curve ab
Number of years from the present at which the ore body is worth $100,000.
Per cent

Present value of this profit =$148,300
Taxes on this amount at 2 per cent =$ 2,966 00

The above figures show that in cases of comparatively short-lived mines at least, the amount of the general property tax is not nearly sufficient to influence perceptibly the policy of the company with respect to the rate of getting out the ore. In the case illustrated, doubling the annual production would afford a reduction of $2,250 in taxes (at the high rate of 2 per cent). This amount would certainly not equal the entire expense of the necessary additional equipment, and losses due to the increased rate of mining the ore. That is to say, the difference in the present value of the taxes would be more than counterbalanced by the additional cost of mining.

(3) *It is objected that ad valorem taxation on the Finlay method impedes the development of an assured ore reserve, especially for a period more than five or ten years in the future.* The taxes even at 1 per cent of full value, become such a large percentage of the value of an ore body held in reserve for, say, 20 years, as to encourage the skimming off of the richest part of the ore, thereby enabling the company to escape taxation every year for such a protracted period. The general property system of taxation practically renders valueless an ore body held in reserve for over 35 years, if the taxes are levied on assessments made in accordance with the Finlay principles.

The accompanying diagram (Plate VI) will make the situation clear. Suppose, for instance, that an ore body is thoroughly drilled out, and the present value of all probable profits to be derived therefrom, is $100,000. For some reason this ore reserve will remain untouched until the year 1939 (25 years in advance of the present). In 1939, this ore body is worth $100,000. At 6 per cent discount, it is worth at the present time $23,300 (as seen from the curve a-b). At the beginning of every one of these 25 years this sum of $100,000 has a different value, and the ore body a different assessment, increasing as time goes on until it reaches $100,000 in 1939. Taxes are levied each year on these assesments. The curves, o-c^1, o-c^2, o-c^3, o-c^4, show the present value of all these taxes in 1914, at rates of taxation varying from 1 to 4 per cent. The present value, therefore, of all taxes at 2 per cent on this ore body for 25 years is, by the curve o-c^2, $11,650, or 50 per cent of the value of the ore body. The curves, o-d^1, o-d^2, o-d^3, o-d^4, show on the right hand scale the percentage ratio of the present value of these taxes to the present value of the ore body. From an examination of these curves, it is seen that the present value of all taxes at 1 per cent equals the value of the ore body, if it is held in reserve

for 100 years; the present value of all taxes at 3 per cent equals the value of the ore body if it is held in reserve for 33⅓ years, etc.

The conclusion is, that on such a system, an ore body held in reserve for 33⅓ years has no present value, if taxes are levied at 3 per cent. The effect of this tax factor may even be great enough to impede the development of a reserve for more than five or six years in advance, or to cause the wasteful depletion of ore, that would normally last longer than that period.

This diagram is in a way an effective answer to the statements made by C. M. Zander[9] and T. S. Adams[10] at the 1913 meeting of the National Tax Association.

Quoting from C. M. Zander: "The argument is sometimes made that the "conservation" of the mineral resources of the country requires and justifies reduced taxation upon mineral wealth and properties. This argument we believe to be unsound. Taxation exercises an important, but far from a controlling, influence over the rate at which mineral deposits are exploited and exhausted."

Quoting from T. S. Adams:[10] "With reference to the "conservation" argument of President Van Hise and Mr. Miller, I suggest that you have got to prove in some utterly convincing way that a reduction of taxation will result in conservation".

i. *The application of the Finlay principles is founded on a series of somewhat arbitrary assumptions.*

Based on a consideration of past production and future expectation in the case of active mines; and exclusively on future expectation, and results from similar properties, in the case of prospects, a series of values for the following factors is assumed, and used in arriving at valuations:

a. Tonnage of ore reserve.
b. Annual production.
c. Receipts for ore sold.
d. Cost of mining.
e. Rate of interest.

Nevertheless, these are the chief factors that a prospective buyer could take into consideration in determining what he could afford to pay for a property.

j. *One of the chief difficulties encountered in the use of the Finlay system in southwestern Wisconsin is in the necessity of estimating probable future receipts.*

There are two elements of decided uncertainty that must enter into any such calculation. These are the grades of ore to be obtained in the future, and the prices to be received for such ore. For reasons given in Part I, Chapter II, Sections F and G, these quantities are incapable of anything except a very rough approximation.

CHAPTER III: THE ARIZONA METHOD.

A. General Description.

"The present Mine Valuation Law in Arizona, which was passed in the early part of this year (1913) provides that mines shall be assessed by adding together

⅛ of the gross production for the previous year,
4 times the net profit for the previous year and
the value of the improvements.

This then represents 'The Full Cash Value of the Mine' and in most cases amounts to about five times the net annual profit."[12].

In order to apply this system to the "hypothetical zinc mine", as given in Part I, Chapter III, it is necessary to get a clear idea of the meaning of the terms "net profit", and "value of the improvements".

"Net profit"; this is the operating profit (as described on page 19, less a certain sum charged during the year in question for the amortization charge, or "equal annual instalment" is computed as shown, in Part I, Chapter IV, page 24.

The amount to be amortized, or the "wearing value", according to E. B. Skinner,[7] in the case of the "hypothetical zinc mine", is the amount of the original investment ($30,000), less its salvage value ($1,500) that is, $28,500. Allowing investment for the amortization of capital at 4 per cent the annual instalment would be, according to the formula (M) in the section referred to above,

$$28{,}500 \times \frac{(0.04)}{(1.04)^4 - 1} = \$6710.$$

Consequently the annual "operating profits", as given in Table II, Column VI, page 19, less $6,710 will give the annual net profits, as shown in Column IV of the same table.

"Value of the improvements"; The improvements or surface equipment have very little value apart from their association with the ore body. Their intrinsic value depends on the amount of ore yet to be mined compared with the amount of ore reserve at the time of the construction of the surface equipment. There is an insuperable dif-

ficulty in the way of the correct usage of this factor in the assessment. The value of the improvements varies continually with the addition of newly developed ore reserves. For present purposes, it may be considered that the improvements have a certain value per ton of ore mined, thus,

Total ore reserve	300,000 tons
Value of improvements at beginning of the first year	$30,000
Value per ton of ore $\frac{30,000}{300,000}$ =	$0.10

Consequently, the values of the improvements at the beginnings of the different years are

1st year	$30,000
2nd year	(300,000 — 60,000) × 0.10 = $24,000.
3rd year	(300,000 — 130,000) × 0.10 = $17,000.
4th year	(300,000 — 210,000) × 0.10 = $9,000.
5th year	$1500 (salvage value).

The Arizona system has been devised especially to fit the peculiar conditions of the mining industry of that state. Mines of two entirely different classes are found: (a) The porphyry type, where the ore occurs in large masses which are roughly flat. These ore bodies are well blocked out by drilling, for, since the ore is low grade, it is necessary to develop and prove a sufficient tonnage beforehand to warrant the enormous expenditure necessary to treat them; (b) The old type in which "the deposit is more or less nearly vertical, and in which the future is more or less of a gamble * * * The chances, however, are that these mines will last for a good many more years to come, but their lives cannot be predicted with the same certainty as those of the porphyry deposits whose ore is blocked out and whose ultimate life in most cases is known."[12]

It is difficult to find a method of valuation that will apply equitably to mimes of two such widely different types. Consequently a compromise has been made, which is thus described by Mr. Zander, Chairman of the Arizona Tax Commission: "This condition exists; firstly, the method used in Arizona finds only about half the value of the porphyry mines * * * Therefore, manifestly, there is a class of property that is not paying its just tax * * * and because of the difficulty in finding the value of the other classes of mines that are vertical, the situation arises, and is clothed with righteousness, that these mines have the right to escape their proper taxes."[9]

B. Valuations.

Table III ,therefore, contains the necessary data and the resultant assessments according to the Arizona system.

TABLE III.

Year	Time	Gross production	Net profits	Value of improvements	Valuation or assessment
1	Beginning	$158,200	$65,490	$30,000	
	End			$24,000	$305,110
2	Beginning	$146,570	$48,860	$24,000	
	End			$17,000	$230,760
3	Beginning	$121,050	$13,540	$17,000	
	End			$9,000	$78,290
4	Beginning	$116,570	$2,760	$9,000	
	End			$1,500	$27,110

Present value at the beginning of the 1st year of all the above valuations:

$$\frac{\$305,110}{1.06} + \frac{\$230,760}{1.06^2} + \frac{\$78,290}{1.06^3} + \frac{\$27,110}{1.06^4} = \$580,520.$$

C. Criticism of the Arizona Method.

1. *Favorable features.*

a. Its comparative ease of application provided the net profit and the value of the improvements are only approximately computed.

b. The assessment is based very largely on the net profits and the value of the improvements. These two factors constitute in a general way what is here defined as "operating profit". In this respect, the system compares favorably with the essence of the Finlay system.

c. The first factor in the expression for "full cash value", namely, one-eighth of the gross production of the previous year, makes an assessment necessary in years when the mine is producing, but is never-

theless earning no net income. In this respect, the method approximates the results obtained by the general property system in connection with other kinds of property, by which an assessed valuation is placed on all other real and personal property whether profit-earning or not. Consequently, the Arizona system attains an end in the matter of equating the burden on mining and other classes of property, where the Finlay system falls down.

d. The system has great possibilities through a variation of the factors employed. As Mr. Miller of the Arizona Tax Commission states: "Whether the net profits should be multiplied by four, or five or even ten, I am not yet prepared to say, but I firmly believe that the method which we have tentatively adopted is the one which in the long run will redound to the best interest of the state."[12]

e. There is no tax on future production, and no factor that would affect exploration or conservation.

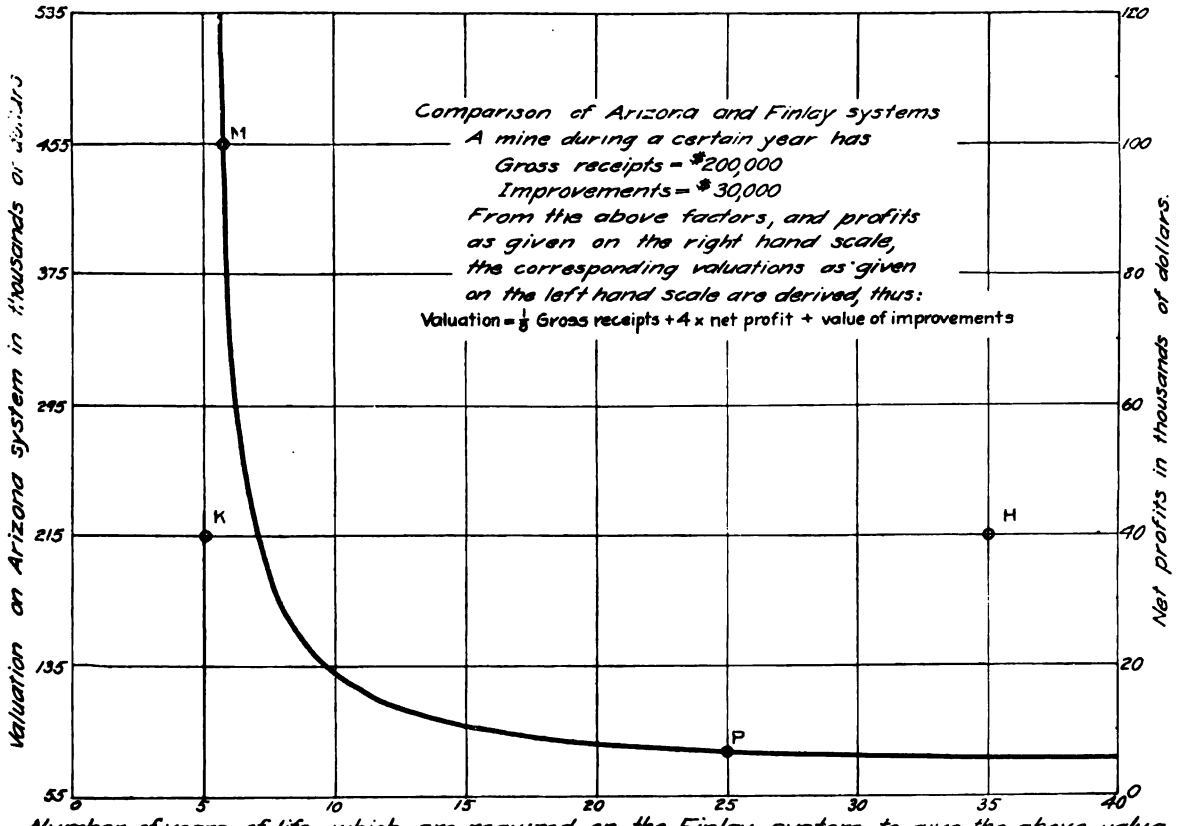
2. *Unfavorable features.*

a. There is no relation whatsoever between the assessed valuation at any time and the sale or purchase value at the same time. Consequently, the system bears no relation to ad valorem taxation, on which the general property system is founded.

b. There is no allowance made for the decreasing value of a property, due to the progressive depletion of ore reserves. This involves a marked injustice as between two mines, each earning a net profit of $100,000 per annum, for instance, when one mine has a residual life of one year, and the other a lease of life of, say, 20 years.

c. According to the statement of C. M. Zander, quoted on page 48, the system shows partiality toward mining property, by allowing it to escape its proper share of taxation.

d. The system is decidedly unjust when applied to mines of widely different terms of life. According to the statement of the Arizona Tax Commission, mines are practically put on a five year basis. As a matter of fact, as may be seen by referring to the computations under Chapter VII, B, below, the use of the factors employed in the general expression puts the mines on a nine year basis instead of a five year one. If a mine should have a life of nine years, for instance, the present value of all its annual valuations (provided the case is a post-mortem) would be approximately 45 ($=9+8+7+\ldots+1$) times the annual net profit. Distributing this over a period of nine years, the factor by which the annual profit would have to be multiplied would be about 5. This is practically the factor used at present, if the value of the improvements plus $\frac{1}{8}$th of the gross production are ap-


Comparison of Arizona and Finlay systems
A mine during a certain year has
Gross receipts = $200,000
Improvements = $30,000
From the above factors, and profits
as given on the right hand scale,
the corresponding valuations as given
on the left hand scale are derived, thus:
Valuation = 1/8 Gross receipts + 4 x net profit + value of improvements
M
K
H
P
535
455
375
295
215
135
55
120
100
80
60
40
20
0
0
5
10
15
20
25
30
35
40
Valuation on Arizona system in thousands of dollars.
Net profits in thousands of dollars.
Number of years of life, which are required on the Finlay system to give the above valuations, using the corresponding sum for net profits (Interest at 6 per cent.)

proximately equal to the annual profit. Consequently the system might compare very favorably in total results, with the ad valorem system, if applied to mines of nine years residual life. (For further explanation of this computation, see Chapter VII, Section B.)

c. There are serious difficulties in the way of obtaining values for the different terms of the expression for "full cash value".

Firstly, should gross receipts represent the gross value of the products of the mine at the mine, or should the transportation and other expenses necessary to move the products to their place of sale be deducted therefrom? This feature has given rise to considerable trouble in the state of Colorado.

Secondly, the determination of the true net profit depends on the amount of earnings, which should properly be reinvested each year for the amortization of the capital outlay. This amount can only be correctly estimated when the full knowledge of the mine's future life is available.

Thirdly, the value of the improvements or surface equipment is practically zero except in relation to the tonnage of ore yet to be mined. To get a value dependent on the amount of reserve, the future production of the mine must be known or estimated.

The last two difficulties involve the essence of the Finlay system, which is based on the best possible estimate of the future production of the mine. Consequently, one of the chief objections to the Finlay system becomes one of many equally serious objections to the Arizona system.

f. The accompanying diagram (Plate VII) presents an interesting criticism of the Arizona method. Given the gross receipts, the net profits, and the value of the improvements of a mine during a certain year, the diagram shows the number of similar years of life that would be necessary to give, according to the Finlay system, the valuation obtained by the use of the same figures, according to the Arizona method. For instance, the gross receipts and the value of the improvements remain constant at $200,000 and $30,000 respectively. Suppose the net profits are $50,000. The valuation on the Arizona basis would be

$$\tfrac{1}{8}\text{x}200{,}000+4\text{x}50{,}000+30{,}000=\$255{,}000.$$

This amount is represented on the left hand side of the diagram directly across from the figure, $50,000, on the right hand side. To obtain the valuation $255,000, on the basis of $50,000 annual profits, according to the Finlay method, the amount $50,000 must be multiplied by a factor, $\frac{255{,}000}{50{,}000}$, or 5.10. According to the table given on page 46 of Finlay's "Cost of Mining", (see also Plate XI at end of

this paper), $5.10 is the present value of an annual dividend of $1.00 extended over 6.58 years, interest being taken at 6 per cent. Therefore, if the mine continued 6.58 years, and produced annual net profits of $50,000 its present value on the Finlay system would be $255,000. The terms of life expressed in years necessary to give the Arizona valuations by the Finlay method, may be directly obtained from the diagram by reading from the figure representing annual profit directly across to the curve, and from this point of intersection directly downward to the bottom line.

The following inferences may be drawn from the diagram.

a. A mine, making a large gross production, and a small net profit, would be required to have a long lease of life in order to justify the Arizona assessment, on the Finlay basis. Example: Point B on the diagram.

b. A mine, making the same gross production and a large net profit, would be required to have a short lease of life to justify the Arizona assessment on the Finlay basis. Example: Point M. on the diagram.

c. When the net profits get infinitely great the term of life must be at least 4.78 years on the Finlay basis to give the Arizona assessment.

d. The Arizona system undervalues all mines represented by points above the curve, (point H. for example) and overvalues all mines represented by points below the curve (point K, for example).

CHAPTER IV: THE COLORADO METHOD.

A. General Description.

Previous to 1913, the valuation for mine assessment was 25 per cent of the value of the gross output of the preceding year, unless the net exceeded 25 per cent of the gross, in which event the net was used as the assessable value.[13]

According to a change in the law (Chapter 139—Laws of Colorado) in 1913, "precious metal mines are to be assessed on 50 per cent of the gross output, instead of 25 per cent as heretofore; and in addition to the 50 per cent of the gross output, there is to be added the entire net output, if any exists."[14]

B. Valuations of the "Hypothetical Zinc Mine" on the 1913 Basis.

1. End of 1st year,

Valuation ..... $\frac{\$153,200}{2} + \$65,490 = \$142,090.$

2. End of 2nd year,

Valuation ..... $\frac{\$146,570}{2} + \$48,860 = \$122,145.$

3. End of 3rd year,

Valuation ..... $\frac{\$121,050}{2} + \$13,540 = \$74,065.$

4. End of 4th year,

Valuation ..... $\frac{\$116,570}{2} + \$2,760 = \$61,045.$

5. Present value at the begining of the 1st year of all above valuations = ... $353,350.

C. Criticism of the Colorado Method.

This method levies a tax on net income and gross receipts without relation to the life of the mine or its sale value. It has very little to commend it, beyond its apparent simplicity of application. Owing to the difficulty of defining gross receipts and net profits (as discussed on page 51) this simplicity is not so real as apparent.

1. *Favorable features.*

a. The system approaches, to a certain extent, the results of the general property system in relation to other property, in that it assesses a mine on gross output during years when the business is being conducted without net profit. This is in accordance with the treatment of other classes of property. (See Part II, Chapter VII, pages 66 and 67).

b. There is no tax on probable future production, and no factor that would affect exploration or conservation.

c. If the net profit were approximately equal to ¼ of the gross proceeds, then this system would compare favorably in total results with the Finlay system for mines with a life of about five years. (Compare Part II, Chapter III, pages 50 and 51).

2. *Unfavorable features.*

a. It is impossible to determine the true net profits (compare discussion on page 51).

b. It does not tax properties that are valuable, but unproductive. In the words of C. P. Link:[18] "It penalizes the producer ..... In Colorado, the heavy mine owners don't produce the ore. They hold the property for speculation."

c. According to Plate VIII which is constructed in the same manner as Plate VII, described on page 51, the Colorado system undervalues all mines represented by points above the curve, and over-values those represented by points below the curve.

For example, point M represents a mine with an annual profit of $50,000 and a residual life of 15 years. On the basis of present value of future profits, this mine is worth 50,000 x 9.09* = $454,500. According to the Colorado system it is assessed at $150.000. The mine represented by P is also assessed at $150,000 although it is only worth 50.000 x 1.82* = $91,000.

That is to say, the Colorado assessments have no relation to the intrinsic value of a property.

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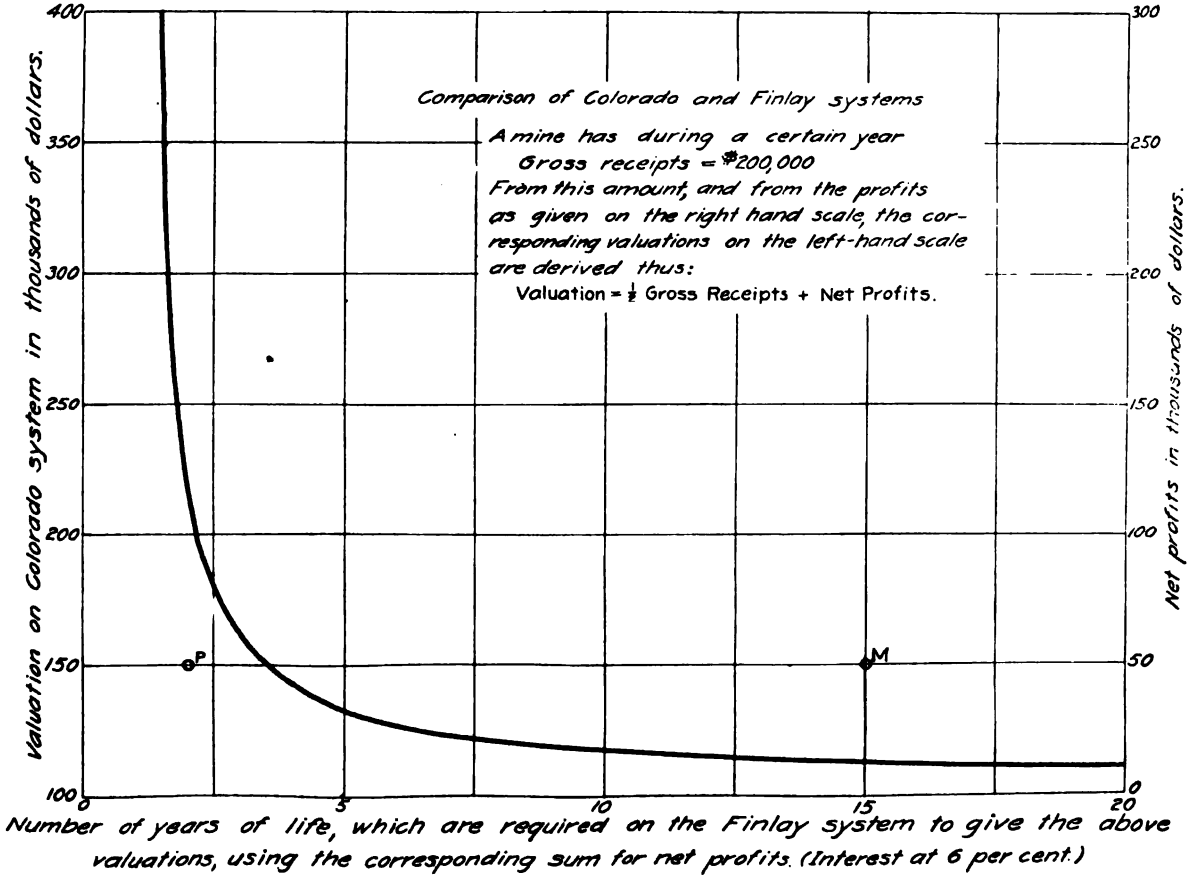
* See Finlay. The Cost of Mining, page 46. (Interest rate 6 per cent.) (Plate XI.)


Comparison of Colorado and Finlay systems
A mine has during a certain year
Gross receipts = $200,000
From this amount, and from the profits
as given on the right hand scale, the cor-
responding valuations on the left-hand scale
are derived thus:
Valuation = ½ Gross Receipts + Net Profits.
Valuation on Colorado system in thousands of dollars.
400
350
300
250
200
150
100
Net profits in thousands of dollars.
300
250
200
150
100
50
0
P
M
0
5
10
15
20
Number of years of life, which are required on the Finlay system to give the above
valuations, using the corresponding sum for net profits. (Interest at 6 per cent.)

CHAPTER V: GROSS RECEIPTS AND TONNAGE TAX METHOD.

A. General Description.

The tonnage tax has been frequently advocated as a simple and fair method to apply to mines. It is a tax on ore taken out of the ground, and like the systems employed by Arizona and Colorado, it is based on results of mining rather than on expectations. The suggestion of a tonnage tax for southwestern Wisconsin has been made by some of the operating companies, on the belief that owing to the local conditions concerning royalty and the incidence of real property taxes, the results would be more equitable as between taxpayers.

Under the Constitution of the state of Wisconsin real property must be assessed at its "full cash value", according to the general property system. Other systems of mine taxation should for the present, at least, be judged in the light of the results obtained by the general property system, when sufficient data are available to permit of the equitable application of that system.

A tonnage tax may be of two varieties: (a) It may be a flat rate levied on each ton of ore produced, or (b) it may be graduated according to the values of the different grades of ore.

B. Criticism.

1. *The flat rate tonnage tax* has very little in its favor except that it is a tax on past rather than future production, and that in order to compute its amount each year only annual production figures are required. It does not even have the advantage of bearing a relation to the fee owner's interest in a property, because of the fact that it takes no account of the sale prices of ore. For the above reasons, the flat rate tax may be dismissed from this discussion, as being of very little consequence.

2. *The graduated tonnage tax and gross receipts tax.*

In such a system the rate would vary with the prices of ore. That is to say, when concentrates sell from \$10 to \$15 a ton the rate would be r_1; when they sell from \$15 to \$20 a ton the rate would be r_2; when they sell from \$20 to \$25 a ton the rate would be r_3, etc. This method approaches in results a gross receipts tax, where a certain percentage of the amount received for ore constitutes the tax. Both of these sys-

tems have for all practical purposes the same advantages and disadvantages, and are therefore discussed under the same heading.

(a) *Advantages.*

(1) In order to determine the amount of the tax, only sales and production figures are required. The necessity of asking companies to report costs and net earnings is obviated. The tax is levied on definite quantities, and not on indefinite quantities such as the present worth of probable future profits.

(2) Since the fee owner in southwestern Wisconsin obtains a definite percentage of the gross receipts as royalty, and usually pays the taxes on the mineral rights, a graduated tonnage or gross receipts tax would in all cases be in proportion to his interest in a property.

(3) Since such a tax is on past production, it would in no way impede the exploration and development of ore bodies.

(b) *Disadvantages.*

(1) A graduated tax on tons of concentrates produced or a tax on gross receipts would have no relation at any one time to the sale value of a property.

(2) The present value of all taxes on this system would have absolutely no relation to the present value of all taxes on "full cash value" or "rational" valuations made, according to the standard ad valorem method. If all the mill dirt mined in the district were of approximately the same grade and all mining costs per ton of dirt were the same, then the cost of producing a ton of concentrates in all mines would be a definite amount. In this case only could a gross receipts tax be equated in a general way with ad valorem taxation.

(3) Such a tax would have no relation to profits or, the ability of the property to pay.

(4) It would tax productive mines, even if they were producing at a net loss.

CHAPTER VI: METHODS USED BY OTHER JURISDICTIONS.

While no attempt will be made to discuss the various other methods described in the literature, a brief synopsis of a few systems may afford some interesting suggestions.[16] It is interesting to note that in these jurisdictions a distinction between mines and other real property is recognized for purposes of taxation.

A. Wyoming.

"All mines and mining claims from which gold, etc., may be produced shall be taxed in addition to surface improvements . . . on the gross product thereof as may be prescribed by law."

(Constitution, Article XV, Section 3)

B. South Carolina.

"General Assembly shall provide by law for uniform and equal taxation of all property; *except* mines and mining claims, the products of which *alone* shall be taxed."

(Constitution, Article X, Section 1)

C. Nevada.

"The Legislature shall provide by law for a uniform and equal rate of assessment and taxation, and shall prescribe such regulations as shall secure a just valuation for taxation of all property, real, personal, and possessory, except mines and mining claims, when not patented, the proceeds alone of which shall be assessed and taxed, and, when patented, each patented mine shall be assessed at not less than five hundred dollars ($500), except when one hundred dollars ($100) in labor has been actually performed on such patented mine during the year, in addition to the tax upon the net proceeds."

(Constitution, Article X, Section 1)

In connection with the above law, it may be interesting to note the method of computing net proceeds, as prescribed by the Nevada Tax Commission for 1913.[15]

"The net proceeds of any mine shall be determined as follows: From the actual value of the gross yield (in any quarter) shall be deducted the sum of the following items of expense:

"(1) Management: All necessary current administrative expenses, excepting: (a) Federal, state, or county taxes; (b) Payments of interest on bonds or other indebtedness, (c) Expenses of maintaining offices other than the mine office.

"(2) Cost of extracting: (a) All necessary current mining expense (not including apportionment of general or administrative expense) including expense of contemporaneous development and exploration of the mine itself. (b) A depreciation charge .....

"(3) Cost of transportation .....

"(4) Cost of reduction or sale ....."

D. British Columbia.

"The law is that every person owning, managing, leasing or working a mine has to pay 2 per cent on the assessed value of all ore or mineral-bearing substances raised, gotten, or gained from any lands in the province which have been sold or removed from the premises, less the actual cost of transportation to mill or smelter and the cost of smelting or milling; so that practically 2 per cent is charged on the net smelter returns of the value of the ore"—

J. B. McKilligan, Tax Collector of British Columbia.[16]

E. Ontario.

The basis of taxation as laid down in the law of 1907 is *net profits:*

"All mines which yield an annual profit above the exempted amount of $10,000, pay a flat rate of 3 per cent on such excess.

"The tax in any year is based upon the profits of the preceding year."[16]

CHAPTER VII: THE EQUATED INCOME METHOD.

A. General Statement of the Problem.

In order that mining property might bear its fair share of the expenses of government, as compared with other kinds of property, it would be necessary, under the existing state of affairs, that any proposed methed of assessment of mining property should yield on the whole approximately the same income, as the present property tax when levied on "full cash value" assessments. With this criterion clearly in view, the problem was set of finding some tax rate to be applied annually to the past year's income that might take the place of the present ad valorem system of taxation.

It has been shown that the "rational valuation" of a mining property at any time is the present value of all future profits, or the sum of money which a purchaser would be willing to pay for a property, if he had access to all the details. (See Part I, Chapter IV). From this point of view, profits are construed to mean "operating profits," that is the difference between receipts and the actual costs of getting the ore out (neglecting entirely in the latter item, such factors as royalty, interest and amortization charges).

The problem, therefore, is to find the tax rate, which, when levied on the profits each year, will give approximately the same total results as those given by the present general property tax when applied annually to valuations based on the present values of future profits.

B. Suggested Solution of the Problem.

As a basis for the computation, an example of a mine lasting 4 years was assumed, which made an "operating profit" of p_1, p_2, p_3, and p_4 during the first, second, third and fourth years respectively. The rate of interest is taken to be 6 per cent.

Valuations are worked out for this mine at the beginning of each year by the same method as that used in the valuations of the "hypothetical zinc mine" from a post-mortem examination (Part II, Chapter I).

The following are the data used:

Year	Operating profit	Valuation
1	p_1	v_1
2	p_2	v_2
3	p_3	v_3
4	p_4	v_4

In the table of present values of annual dividends as given in H. C. Hoover's "Principles of Mining"[18] will be found the factors used below.

Therefore.

$$\begin{aligned} v_1 &= 0.943p_1 + 0.890p_2 + 0.840p_3 + 0.792p_4 \\ v_2 &= \quad 0.943p_2 + 0.890p_3 + 0.840p_4 \\ v_3 &= \quad\quad 0.943p_3 + 0.890p_4 \\ v_4 &= \quad\quad\quad 0.943p_4 \end{aligned}$$

The present value of all the above valuations (V_{pv}) at the beginning of the 1st year

$$= v_1 + \frac{v_2}{1.06} + \frac{v_3}{1.06^2} + \frac{v_4}{1.06^3}$$

$$= v_1 + 0.943v_2 + 0.890v_3 + 0.840v_4$$
$$= 0.943p_1 + 1.780p_2 + 2.520p_3 + 3.168p_4 \quad (V_{pv})$$

The present value of all the "operating profits" (P_{pv}) at the beginginning of the 1st year

$$= \frac{p_1}{1.06} + \frac{p_2}{1.06^2} + \frac{p_3}{1.06^3} + \frac{p_4}{1.06^4}$$

$$= 0.943p_1 + 0.890p_2 + 0.840p_3 + 0.792p_4 \quad (P_{pv})$$

Now, the present value of all taxes on the valuations v_1, v_2, v_3, and v_4, at the rate r, is equivalent to $\frac{r}{100} \times V_{pv}$.

It is required to find the value of a rate, q, which, when applied to the present value of the profits, P_{pv}, will give an amount of taxes equal to $\frac{r}{100} \times V_{pv}$.

Therefore, since

$$\frac{q}{100} \times P_{pv} = \frac{r}{100} \times V_{pv}$$

$$q = \frac{V_{pv}}{P_{pv}} \times r$$

Consequently, if the general property tax rate should be multiplied by the factor $\frac{V_{pv}}{P_{pv}}$ and the resultant rate applied annually to the operating profit, it would yield approximately the same revenue, as the actual general property rate when applied annually to "full cash value" assessments.

$$\frac{V_{pv}}{P_{pv}} = \frac{0.943p_1 + 1.780p_2 + 2.520p_3 + 3.168p_4}{0.953p_1 + 0.890p_2 + 0.840p_3 + 0.792p_4}$$

By giving p_1, p_2, p_3, and p_4, different values from zero to infinity, it is found that the limiting values of the expression are 1 and 4, depending on whether the profits are greatest at the beginning or end of life.

If the profits are the greatest during middle life, then the value of the factor approaches 2.5, or $\frac{(1+4).}{2}$

If the profits each year are the same, that is, on the basis of an average annual profit, the value of the factor becomes 2.43.

C. Inferences From the Solution.

The following inferences are based on the assumption that on the average the profits of a mine during each year of life are approximately equal. Under conditions of a constant spelter and ore market, however, it might be more reasonable to assume that the profits would be greatest during the early part of middle life. The prices of ore are an independent variable affecting profits, and raise and lower the profits without respect to the year of the mine's life or to mining costs. For these reasons, more equitable results would likely be obtained on the assumption of equal annual profits. Furthermore, such an assumption is in harmony with the principles of the Finlay system.

1. By giving the hypothetical mine different periods of life from 2 to 6 years, the following series of values are obtained for the factor, $\frac{V_{pv}.}{P_{pv}}$

TABLE IV

Life of mine in years	When profits are much the greatest at the beginning of life	When profits are much the greatest at the end of life	When profits are much the greatest in middle life	When profits are about equal each year of life (average case)
2	1 to 1.5	1.5 to 2	1.5	1.48
3	1 to 2.	2. to 3	2.	1.96
4	1 to 2.5	2.5 to 4	2.5	2.43
5	1 to 3.	3. to 5	3.	2.89
6	1 to 3.5	3.5 to 6	3.5	3.34

2. In order to obtain a value for this factor to apply uniformly in the case of all the mines of the zinc and lead districts, it is necessary to assume an average life for the mines.

An estimate of the average life of the mines operating in 1911 was made by W. O. Hotchkiss,[17] from information obtained from mining operators, ore buyers and others interested in the mining business, and was found to be 6.8 years. The average total life of the mines valued for the 1914 assessment is between 4.5 and 5 years. From this and other information it is probable that a conservative estimate of the average total life of the mines will, for some time at least, be about 4 years.

3. On the basis of an average life of 4 years, and assumed equal annual profits, the value of the factor, $\frac{V_{pv}}{P_{pv}}$ would be 2.43.

4. For the sake of brevity in the subsequent discussion, this method of taxation will be called the Equated Income Tax method.

D. Valuations of the "Hypothetical Zinc Mine."

In order to compare the results of this Equated Income method with those of other methods, when applied to the "hypothetical zinc mine", it would be necessary to multiply the general property tax rate by 2.43. To avoid the necessity of assuming a general property tax rate for making this comparison, the operating profits of the mine are in each case multiplied by 2.43, and the resulting quantities are called, for the sake of the comparison, valuations or assessments.

Case 1: When the actual yearly profits are used.

Year.	Operating profits.	$\frac{V_{pv}}{P_{pv}}$	Valuation.
1	$72,200	2.43	$175,400
2	$55,570	2.43	$135,000
3	$20,250	2.43	$49,200
4	$9,470	2.43	$23,000

Present value of above valuations at the beginning of the 1st year (6 per cent interest).

$$\frac{\$175,400}{1.06} + \frac{\$135,000}{1.06^2} + \frac{\$49,200}{1.06^3} + \frac{\$23,000}{1.06^4} = \$344,900.$$

Case 2: When one-fourth of the total profits is used as an average annual profit.

Average annual profit = ... $39,370
Valuation at the end of each year, 39,370 × 2.43 =..... $95,600
Present value of above valuations at the beginning of 1st year.. $331,000

For the sake of comparison, the results of the Finlay method, when applied to the "hypothetical zinc mine", with the assumption of $39,370 as the average annual profit, are here introduced.

Valuation, beginning of 1st year .....39,370 × 3.38 = $133,000
" " " 2nd " .....39,370 × 2.63 = 103,500
" " " 3rd " .....39,370 × 1.82 = 71,700
" " " 4th " .....39,370 × 0.94 = 37,000
Present value of above valuations at the beginning of the 1st year = $325,600.

E. Criticism of the Equated Income Method.

1. *Introduction.*

Owing to its general equivalence in results to ad valorem taxation, this method of taxation of mines, should it be adopted, should of course be strictly applied to each mining property as a unit. Such an Equated Income tax should be levied, not on the net income of the company operating a mine, but on the income from the mine itself. As stated several times above, the valuation placed on a property for purposes of assessment is intended to represent what the property is worth to a prospective purchaser. From his point of view every dollar received from operation above pure operating cost is clear profit and should be reckoned as such in getting at the present value of the property. In order to have this Equated Income method approximately equivalent, as far as the present value of all taxes is concerned, to a system of valuations based on future profits, it is self-

evident that what is treated as profit in one case should be treated as profit in the other case. That is to say, what is considered as profit from the point of view of the ad valorem system, should also be considered as income from the point of view of the Equated Income method. Consequently, the following criticism is with reference to the results of the ad valorem system as a standard. (See Part II, Chapter I).

In the application of such an Equated Income system, it is believed that it would be more equitable to subdivide profits into two quantities: the one retained by the company as net income, and the other paid to the fee owner as royalty. The tax rate should be applied to each of these separately. A deficit on the part of the company should simply count as zero earnings.

2. *Advantages.*

a. Ease of application. The tax would be entirely based on the results of the past year's operation.

b. It is a tax on past, rather than on future profit. No estimate of futures of any kind for individual mines is necessary.

c. As between different mining properties, the taxes would be in proportion to their various abilities to pay.

d. The division of profits into earnings and royalty admits of the taxation of royalty, when the property is earning nothing, but constantly producing. This is in accordance with the principles of the general property system as applied to other classes of property (see pages 66 and 67.) In this way, the fee-owner who draws his royalty from a profitable mine is not penalized as compared with the fee owner who draws his royalty from an unprofitable mine.

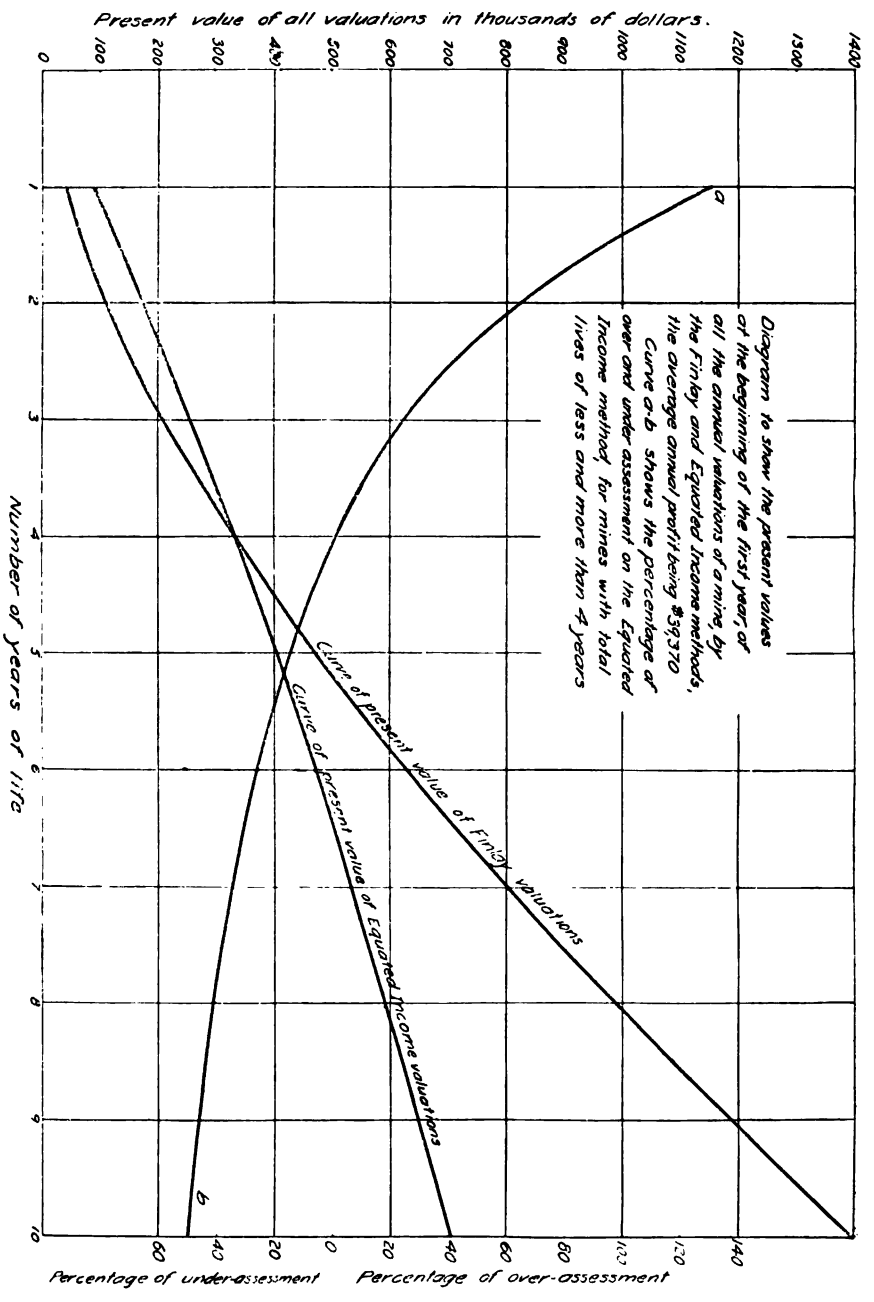
e. The Equated Income system has no effect on conservation of mineral resources, and does not inflict a penalty on the development of an assured ore reserve.

f. If the life of a mine is in the neighborhood of four years, the present value of all taxes under this method is in general equal to the present value of the general property taxes on valuations derived from actual annual profits of the factor 2.43 is used.

g. The tax rate, as shown by the computation, would be low, and in no case would the results be burdensome.

3. *Disadvantages.*

a. The system requires the assumption of an average period of *total* life for the mines of the district. This feature is a serious dis-


Present value of all valuations in thousands of dollars.
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
Diagram to show the present values at the beginning of the first year, of all the annual valuations of a mine, by the Finlay and Equated Income methods, the average annual profit being $39,370
Curve a-b shows the percentage of over and under assessment on the Equated Income method for mines with total lives of less and more than 4 years
a
b
Curve of present value of Finlay valuations
Curve of present value of Equated Income valuations
1
2
3
4
5
6
7
8
9
10
Number of years of life
60
40
20
0
20
40
60
80
100
120
140
Percentage of under-assessment
Percentage of over-assessment

advantage, not so much as far as the zinc district is concerned, but in regard to the extension of the system to the iron mines of the state. This life factor is a cardinal point in the situation, and the greater magnitude of the iron mining operations, especially with respect to the much longer average life of the mines, would absolutely exclude them from participation in the same system of Equated Income taxation, as might be enjoyed by the shorter-lived zinc mines. The adoption of any Equated Income system of taxation, therefore, would require the separation of the iron and of the zinc and lead mines of Wisconsin into distinct classes for assessment purposes.

b. The system here suggested, with the value of the tax rate factor as given, is based on two assumptions, (1) of an average total life of four years, and, (2) that in the average case, the profits will be about the same each year of life. Neither of these assumptions is at all unreasonable. The objectional feature of the procedure implied in the method is as follows: If a mine should last six years for instance, it would not, on the Equated Income basis, be paying its proper share of taxes; that is, it would be paying less taxes than would be derived from a series of annual assessments based on present values of future annual profits. On the other hand, if a mine should last less than four years, say two years, it would be paying more than its proper share. This can be illustrated with reference to Plate IX. This diagram is based on the average annual operating profit of the "hypothetical zinc mine", viz., $39,370. It may be noted from inspection that if a mine lasts 4.06 years (the point of intersection of the two curves) the present value of all valuations (and consequently of taxes) on both the Finlay and Equated Income bases will be the same. The present value of all "rational valuations" of a property with $39,370 annual profit and different periods of life is shown on the left hand scale, opposite the intersection of the Finlay curve and the vertical line through the point representing the period of life. Similarly, the present value of all valuations (valuation here equals 2.43 times the annual profit) on the Equated Income method is similarly shown by the Equated Income curve.

If the mine should have a total life of six years the present value of all "rational valuations" would be $628,000. The present value of all valuations on the Equated Income basis would be $470,000. Similarly, if the mine should have a total life of only 2 years, the present worth of all valuations on the Equated Income basis would be $175,000. The other figure would be $106,600. Corrections could be made by multiplying the factor, 2.43, in the first case, by $\frac{628}{470}$, and in the

second case by $\frac{106.6}{175}$ Such corrections would, of course, require in each case the knowledge of the future life of the mine. The percentage of over and under assessment of any mine, where the Equated Income method is used, is shown on the diagram by the curve a-b, and the scale on the right. These percentages are with respect to the Finlay as a standard.

c. In the case of mines, which show the greatest annual profit in early life, the value of the factor, $\frac{V_{pv}}{P_{pv}}$, should be less than 2.43, so as to avoid over-taxation. Similarly, in the case of mines with the greatest profit at the end of life, the value of this factor should be greater than 2.43 (See Table IV, page 62).

NOTE. Should such an Equated Income system be adopted in place of the ad valorem system, for the taxation of mining property, it would be inadvisable to have the factor, 2.43, fixed by statute. In order to give such a system a degree of elasticity, the determination of this factor should be left to an executive body, empowered to change it in accordance with any change in the average life of the mines.

d. There is no restriction on the holding of ore bodies merely as a speculation.

4. *General.*

It may be objected that the factor, 2.43, when applied to the general property tax rate (which is not greater than 2 per cent), would give an income tax rate (not exceeding 4.86 per cent) that would be too high, especially when applied to short lived mines. Unless it is desired to exhibit special leniency to mining property, it does not seem that this objection is well founded.

On the Equated Income basis, the tax rate, 4.86 per cent for instance, would mean that the general property taxes on mines would be about 4.86 per cent of their annual income. In order to show that this rate is far from excessive as compared with other kinds of property in the state of Wisconsin, the following data was obtained by the writer from the Tax Commission.

a. In 1913, the general property tax on steam railways in Wisconsin amounted to 19.31 per cent of their net income.

b. In 1906, the general property tax on city and village property in Wisconsin amounted to 17.34 per cent of the *gross* rentals derived therefrom. [18]

c. In the same year the same tax amounted to 21.36 per cent of the *net* rentals derived therefrom.

d. "It is clear, therefore, that if an income tax is to bring the same amount of revenue as the present ad valorem property tax on city and village property, the rate of income tax must in all cases be above 10 per cent, and the average rate must exceed 20 per cent on what remains after deducting insurance and repairs."[18].

e. In 1906, the general property tax on farm property in Wisconsin amounted to 13.39 per cent of the *gross* rentals derived therefrom.

"The returns on farm property did not give the amount of insurance and repairs; hence *net* rentals could not be computed."[18]

f. The leading railroads of Wisconsin paid in various years, the following percentage of gross and net earnings as property taxes:[18].

Year	Per cent of gross earnings.	Per cent of net earnings.
1904	5.074	15.68
1905	5.333	15.83
1906	5.197	16.10
1913	.....	19.31

g. In 1913, the general property taxes on 200 industrial and commercial enterprises in Milwaukee, Rock, Douglas, Outagamie and Grant counties, amounted to 12.56 per cent of their net income.

As stated above, these facts present an existing condition of affairs in connection with taxation of various kinds of property, and not necessarily a standard against which to measure ad valorem taxation of mines.

In making a comparison of the above mentioned tax rates with the suggested ones for mines on the basis of the Equated Income tax method the following matters should be taken into consideration.

a. Wasting assets of short life are being compared with other assets of longer life. The ratio of the general property tax to net income ought to be a function of the length of life, and consequently should be greater in the case of a property of a 10 year life, than in the case of one with a 5 year life, for instance.

b. The 1913 results in the case of the 200 industrial and commercial enterprises do not include any cases where taxes were levied although the business was run at zero profit or a loss. The inclusion of such cases, of which many were encountered, would appreciably increase the percentage obtained.

c. In calculating net income, as used above for city and village property and steam railroads, all the legitimate charges were not deducted, in order that all the properties might be on the same basis and elements of doubt eliminated. Were the true net used in every case, the resultant percentage would be larger.

CHAPTER VIII: GENERAL COMPARISON OF THE SALIENT FEATURES OF THE FINLAY AND EQUATED INCOME METHODS.

As stated briefly in Part I, Chapter I, B, the Finlay and Equated Income methods are the only two which, from the point of view of the general property system as a standard, give anything in the nature of equitable results. The especial advantages and disadvantages of each have been mentioned in detail in their respective chapters. It is not the purpose of this paper to advocate any particular system. A concise summary of the chief merits and demerits of both systems is presented herewith in the way of a comparison.

1. The Finlay system bases its results on an estimated residual life of each mine to be assessed. The Equated Income method bases its results on an estimated average total life of all the mines of the district.

2. The Finlay valuations are based on future average annual profits. The Equated Income method is based on actual profits of the preceding year. By the series of annual re-valuations the errors that inevitably accompany each estimate of future average annual profits on the Finlay principles, tend to become reduced to a minimum.

3. The present value of all the taxes on a property of about four years life, on both systems, is approximately the same.

4. The Finlay system appraises unproductive, but valuable mining property. The Equated Income system assesses all producing mines, profitable or unprofitable, if worked on the royalty basis.

5. The assessments according to the Finlay method of appraisal bear a definite relation to the sale values of property. The Equated Income method assesses a property in strict accordance with its ability to pay and bears no definite relation to its sale value at any one time.

6. The Finlay method is applied satisfactorily only to well explored, efficiently conducted mining enterprises. The Equated Income method applies almost equally well to all properties.

7. The Finlay system implies the necessity of predicting reserve tonnage, annual production, grades of ore, costs of mining, and future ore prices. The importance of these difficulties in southwestern Wisconsin can hardly be exaggerated. The Equated Income method obviates these difficulties.

8. The Finlay method is cumbersome, as compared to the Equated Income method, in the matter of application.

9. The Finlay method attempts to appraise a mine annually at some amount comparable to its rational sale value. Taxes are levied on an assessment based on this appraisal. The Equated Income method does not directly value a property. It imposes taxes on the income of a property, at such a rate that the present worth of all these taxes is approximately equal to the present worth of taxes on the ad valorem assessments according to the Finlay method when applied to the same mine.

10. Under the present ad valorem system of assessment, the local assessing officers, although, as is to be expected, they usually lack the experience necessary to correctly value a mine, are the final arbiters in the matter of mine assessment. That is to say, the valuation determined for a mine by the experts of the Tax Commission, on the Finlay or some similar method, may or may not be accepted by the local assessors as the assessment. This privilege was used with resulting injustice in several cases in southwestern Wisconsin in 1914. Such a system as the Equated Income, on the other hand, would be automatic in its application, and would not depend on the judgment of the assessors for the determination of an assessment.

CHAPTER IX: GENERAL CONCLUSION.

A graphic comparison of the results of the various methods of appraisal taken up in Part II, as applied to the "hypothetical zinc mine", is shown in Plate X.

(a) The standard set of valuations for this mine, when reduced to their present value at the beginning of the first year, is placed at $248,050. For the determination of this figure, it was assumed that all the details of the operation of the mine were known, (which would only be possible in actual practice after the mines were worked out), and the appraisal is therefore called a post-mortem. (No. 1 in the Plate).

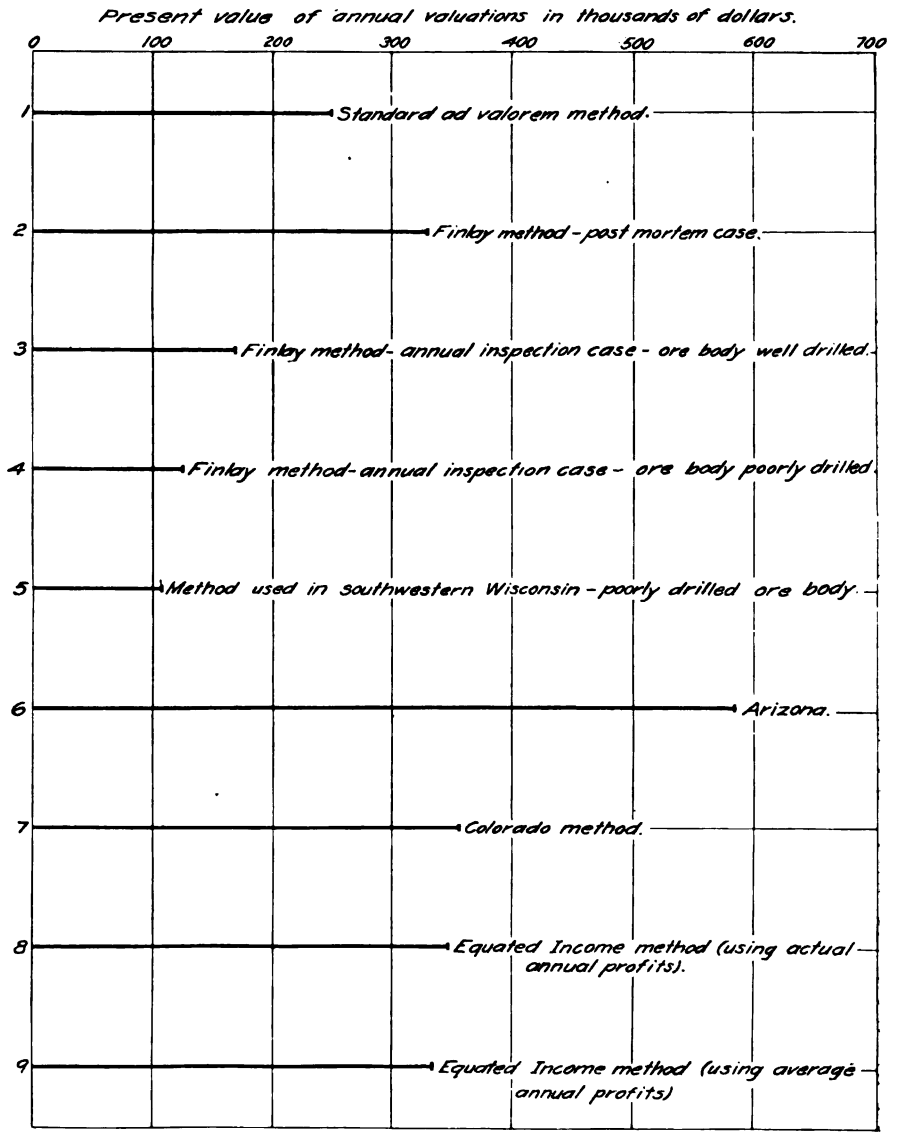
(b) With all the details of operation known, as in the post-mortem case, a series of valuations by the Finlay method was obtained and reduced to its present value, as shown in No. 2. The difference between this result, and that platted as No. 1, is due to the fact that in case No. 1 the various valuations are derived from the present worths of future profits at 6 per cent interest. In case No. 2, on the other hand, the valuations are based on the present values of four equal annual dividends (average annual profit = $39,370), according to the Finlay method. Case No. 2 gives a greater result because the actual profits are greatest at the beginning of life. If these profits had been greatest at the end of life, case No. 2 would have given a smaller result than No. 1.

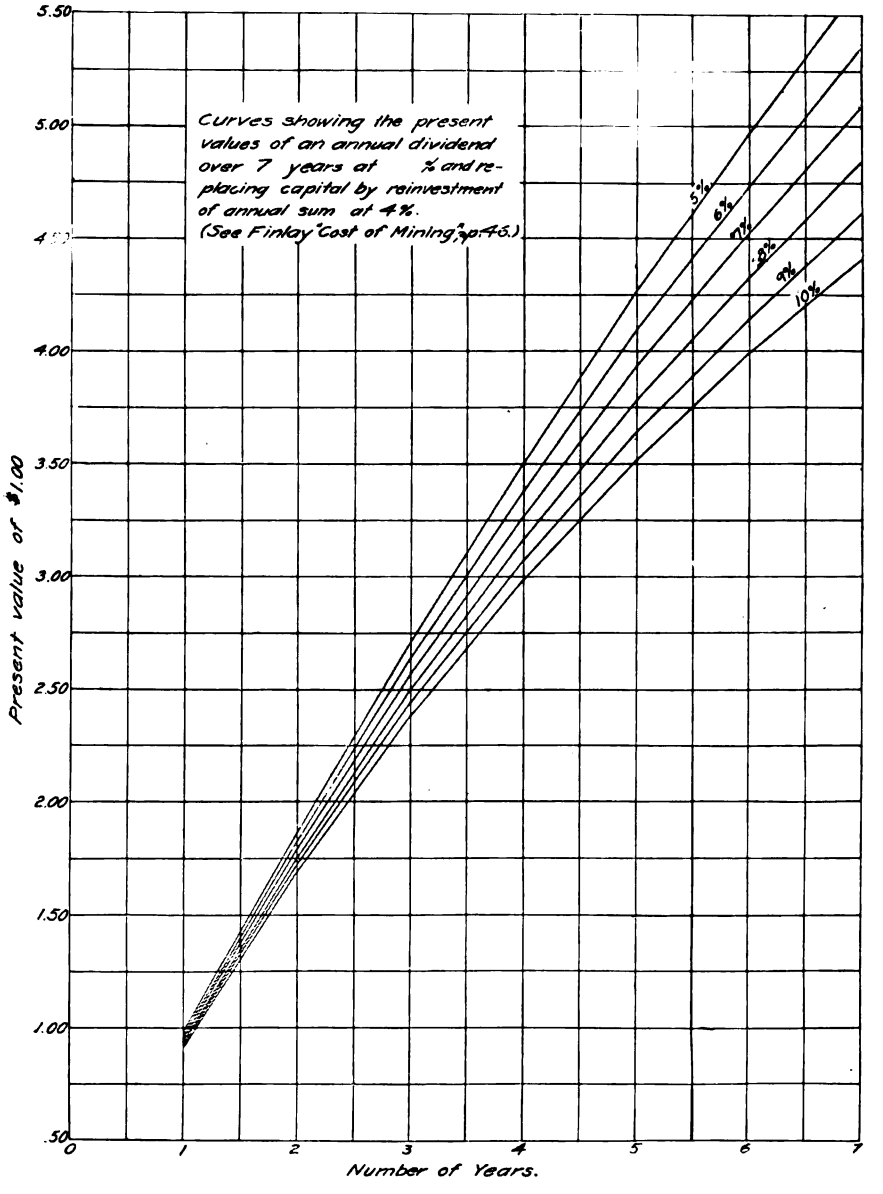
(c) The shortcomings of the Finlay method, when applied to well drilled and poorly drilled ore bodies, are shown in Nos. 3 and 4.

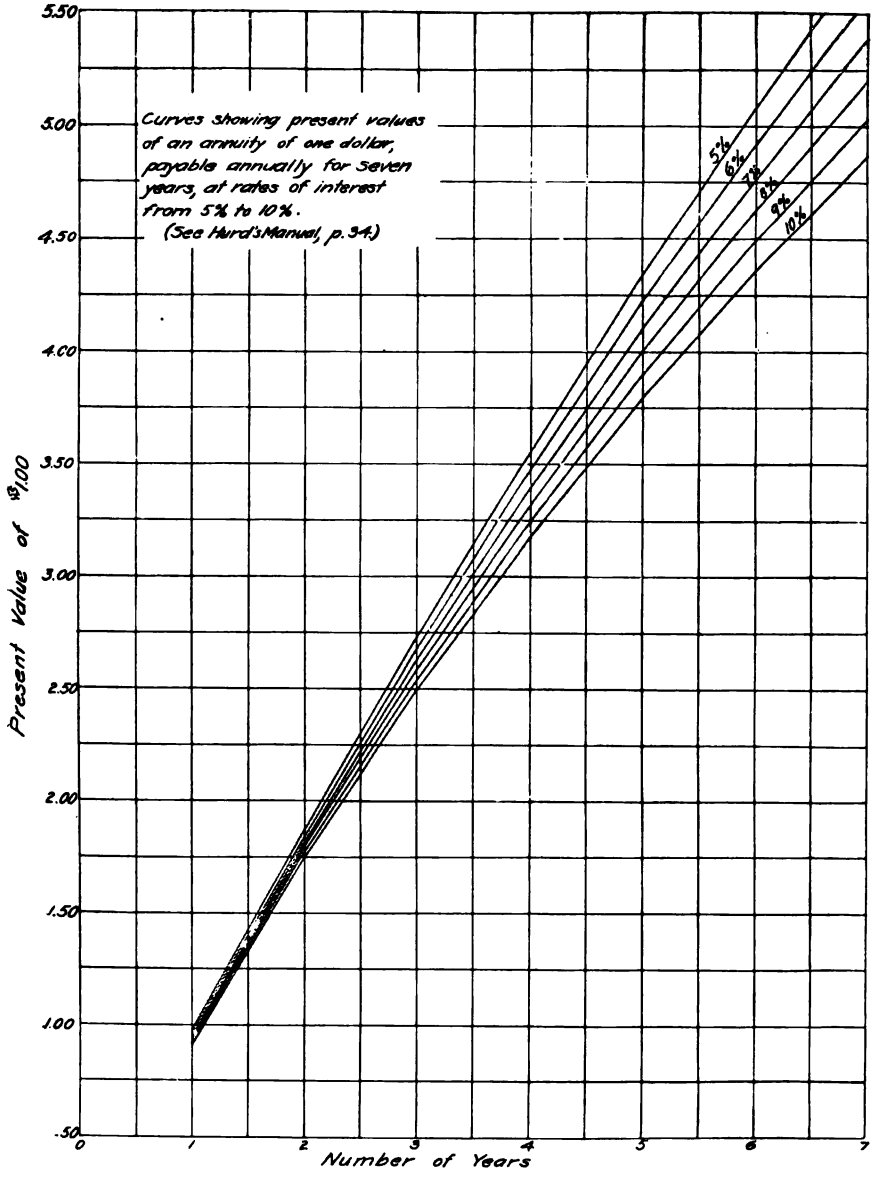
(d) The results of the system used in southwestern Wisconsin in 1914 are shown in No. 5. They fall far below the standard.

(e) The present values of valuations on the Arizona and Colorado systems are shown in Nos. 6 and 7. The reasons for these excessive results are explained in Part II, Chapters III and IV.

(f) Nos. 8 and 9 show the results of the use of the Equated Income method. At first sight, the criticism of the method would be that it gives results at least as excessive as some of the other arbitrary systems. In interpreting these results, however, it must be remembered that, the "hypothetical zinc mine" represents a case of a mine with greatly decreasing annual profits as the end of life is approached. This is due in large part to the falling off in the spelter market, as


Present value of annual valuations in thousands of dollars.
0
100
200
300
400
500
600
700
1
Standard ad valorem method.
2
Finlay method - post mortem case.
3
Finlay method - annual inspection case - ore body well drilled.
4
Finlay method - annual inspection case - ore body poorly drilled.
5
Method used in southwestern Wisconsin - poorly drilled ore body.
6
Arizona.
7
Colorado method.
8
Equated Income method (using actual annual profits).
9
Equated Income method (using average annual profits)


Curves showing the present values of an annual dividend over 7 years at % and replacing capital by reinvestment of annual sum at 4%.
(See Finlay "Cost of Mining", p. 46.)
5%
6%
7%
8%
9%
10%
Present value of $1.00
5.50
5.00
4.00
3.50
3.00
2.50
2.00
1.50
1.00
.50
0
1
2
3
4
5
6
7
Number of Years.


Curves showing present values of an annuity of one dollar, payable annually for seven years, at rates of interest from 5% to 10%.
(See Hurd's Manual, p. 34.)
5%
6%
7%
8%
9%
10%
Present Value of $1.00
5.50
5.00
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
.50
0
1
2
3
4
5
6
7
Number of Years

shown in Table I, page 19. The "hypothetical zinc mine", in this respect, does not represent an average case. If the profits were about the same each year of life, the standard set of valuations, represented by No. 1, would be represented by a line about equal in length to No. 2.

The formulation of an equitable system of mine assessment and taxation is fraught with numerous difficulties. Such a system would be required to treat all properties in the same manner, it would have to be applicable to the peculiar condition of the mining industry in the district where it is applied, and it would need to be clearly constitutional, and one that could be easily and uniformly enforced. It may be argued with some justice that the general property system is not adapted to the taxation of mines, in that mining property is a wasting asset, and not of the same nature as real estate.

The real test of the suitability of the Finlay and Equated income systems to a mining district, is in their practical application. Whether it is advisable to continue using the Finlay principles, and to educate the mining constituency as a whole up to the requirements of that standard, even though it cause inequitable assessments at first, or to adopt some more or less arbitrary method that would tax the various properties according to their ability, even if the assessments should have no direct relation to the value of the properties, is a question that demands the most careful consideration of both the mining community and public officers.

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